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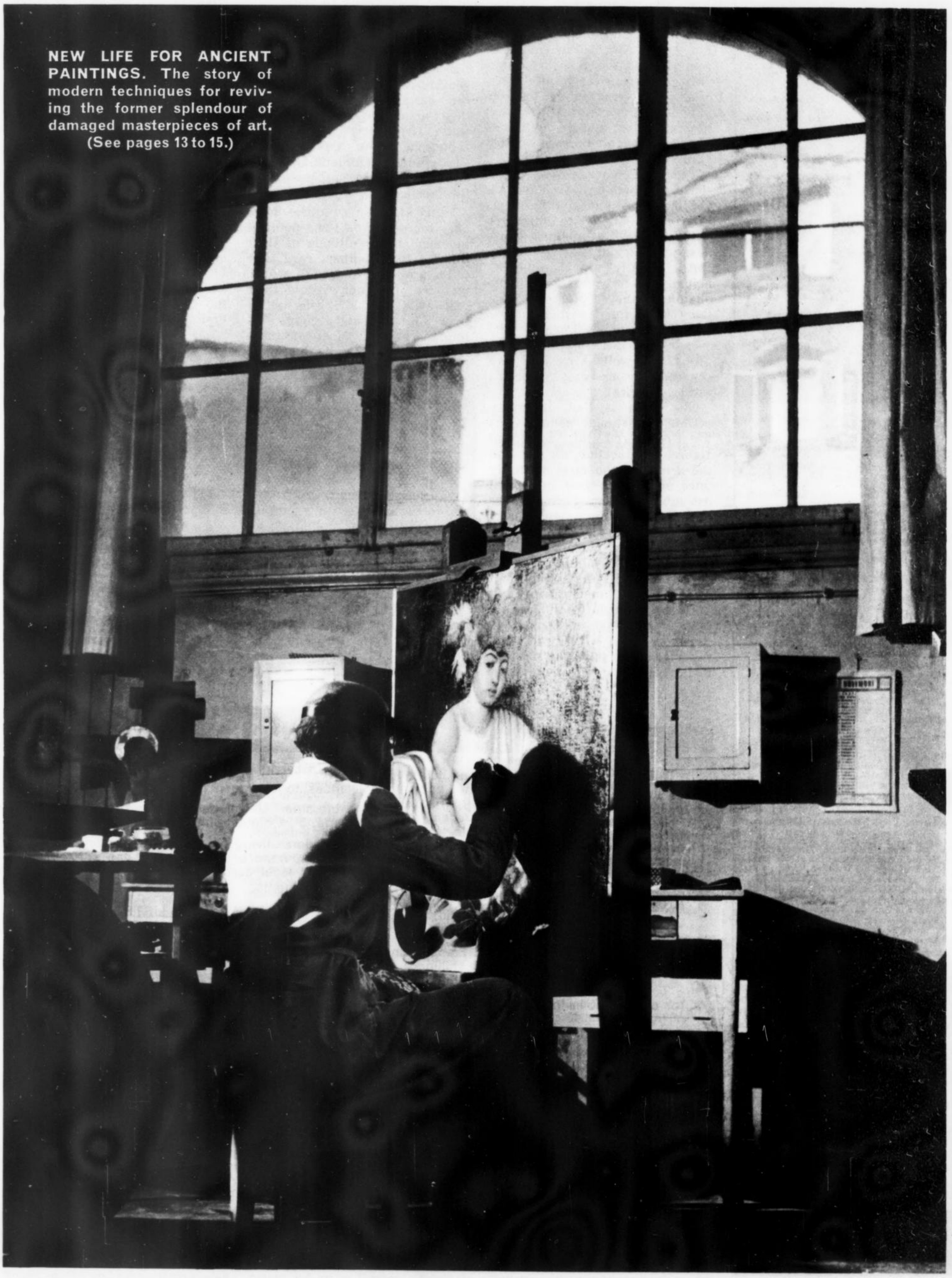

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(See pages 13 to 15.)

Courier

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# Reaching down to a nation's 'grass roots'

THE work of Unesco is one of a great crusade for international understanding and betterment founded on the belief that co-operation between the peoples of the world in furthering education, science and culture can be a deciding force in the search for a lasting peace.

When Unesco was created in 1946, it elaborated a scheme which was without precedent in world organization. This was the basic concept of national commissions, designed to permit governments to carry out Unesco's world programme on the national and community level through public and private organizations reaching down to the "grass roots" of the country.

Today Unesco has 64 member states, of which only six have not yet formed national commissions. Fifty-eight national commissions out of a total of 64 member states is indeed an impressive figure. But is it really? Do these bodies actually serve as Unesco's channel to the people? Are they the centres for dynamic Unesco movements made up of civic, labour, farmer and student groups, as well as cultural and scientific associations in each of these countries?

The truth is that, in many countries, national commissions are composed of important figures in education, the arts and the sciences who meet solemnly once or twice a year in formal assemblies. Except for a number of outstanding exceptions, many Unesco national commissions have little real contact with the people they are supposed to represent, and some are in point of fact almost inoperative.

Does this mean that there is a lack of desire or willingness to do more? No. It is not that national commissions do not care to increase their effectiveness or undertake concrete projects in which city and rural groups can directly participate. In practically all cases they do. But organizing such projects is a complex matter. It often requires special funds and at least a small, permanent Unesco "relations staff" to plan and organize them and then get them under way. Most Unesco commissions do not have funds for either.

Several weeks ago this problem came to the forefront in Bangkok, when Unesco brought together for the first time the national commission representatives from the vast area of South Asia and the Pacific. Afghanistan, Australia, Cambodia, Ceylon, India, Indonesia, Laos, Pakistan, the Philippines, Thailand, Burma and Viet Nam were represented at the meeting.

Many of these countries have only recently won their political independence. Millions of their people can neither read nor write, are under-fed, in ill health, and are often unaware of their responsibilities as citizens and of their fundamental rights as human beings. Most of them are among the underdeveloped countries which the United Nations is aiding through its programme of technical assistance for economic development.

They met to discuss the implementation of those parts of Unesco's programme of particular urgency for their region. These included fundamental and adult education, free and compulsory elementary schooling, teaching and popularizing the sciences, the development of public library systems, and technical assistance for raising standards of living.

The delegates adopted a number of specific measures for increased action. But one thing became very clear. The job facing these countries was a tremendous one. Raising the standard of living of the great mass of their peoples, providing them with fundamental education in such complex fields as literacy, health, technology and civics is far too difficult a job to be tackled by government ministries single-handed. It requires the mobilization of all the resources of a country. It means that students and scholars, scientists and village teachers, workers and farmers must all get together and help.

And here is where the disturbing bottleneck became apparent. Few of the grave problems that the national commission delegates were considering would really be solved unless the commissions themselves could play a more direct role and could mobilize the potential resources of their countries. The bottleneck lay in the commissions' own lack of resources. They had neither a minimum budget nor the minimum Unesco "relations staff" for their commissions, and the administrative and programming techniques to undertake national or community campaigns were almost completely lacking.

A cry for help went up from the delegates of South Asia and the Pacific. It was a plea for some measure of outside assistance, for the assignment of one or two skilled national campaign organizers to each commission for a few months to enable them to "start the ball rolling."

This is the important challenge to Unesco, and its most active and best organized national commissions, that has come from the Far East. On the response they make depends the future development of the national commissions and the success of Unesco's programme in that part of the world.

## TO OUR READERS

**Despite increased production costs, the price of the COURIER has remained unchanged during the past year. The sharp rise in the cost of paper and printing in recent months has, however, made it impossible to continue publication at our present rates. We regret to inform our readers, therefore, that after March 31 1952, new rates will go into effect as follows:**

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Island villages on Lake Pàtzcuaro are among those in which the Centre's students are working. Here their main task is to help the islanders to solve the economic problems which are the result of an ever-dwindling supply of fish.

# REPORT ON PATZCUARO

## One of the world's most unusual social experiments

*by Tibor MENDE*

**THIS is the second in a series of articles on Latin America by Tibor Mende, author and journalist, who recently visited Central and South America on assignment for Unesco. In last month's Courier, Mr. Mende reported on Unesco's pilot project in education in the Marbial Valley of Haiti. Below, he tells of his visit to Pátzcuaro, in the State of Michoacán, Mexico. Here on May 9, 1951, Unesco and the Organization of American States launched the first regional centre to train leaders of teachers of fundamental education for Latin America. The Pátzcuaro centre is a workshop producing men and tools to be used for creating similar workshops elsewhere in Latin America. The fifty teachers Pátzcuaro trained last year cannot by themselves do much to reduce Latin American illiteracy or to alleviate the poverty that accompanies it. But they are the beginning of a chain process of teaching other teachers, which gradually will provide the human and material means of coping with the problem. This is the key to the existence of Pátzcuaro, and also to the network of regional education centres Unesco is setting up throughout the world.**

IN addition to its famed scenery and Friday market, the Mexican town of Pátzcuaro recently acquired a third distinction. It has become the headquarters of one of the world's most unusual social experiments. As its "laboratory," the experiment has 18 villages framed by the scenery of Michoacán and peopled by the bronzed descendants of Tarascan Indians who are still more attached to their own musical language than to the Spanish of the rest of the country.

Six thousand feet up among the hills of the plateau, and only slightly above the incredibly blue lake, Pátzcuaro is one of the most exotic of Mexican towns. Its market, enclosed by motley colonial arcades, has been a meeting place for centuries. On Friday mornings, long before sunrise, Tarascans with their wives and children, in crowded ancient buses, on muleback, or simply on foot, come along the winding road leading from the lake to the town. Old and young, all carry their heavy burden of things produced during the week. It is on this day that they have to exchange the products of their traditional skills for the coins that will buy them the necessities of a rigidly simple life for the rest of the week.

By ten in the morning the square is crowded with people. Baskets and fruits, sashes and *serapes*, fish and fishing-nets, pottery and straw *sombreros* are on display. Among the pyramids of colour, of restless poultry and frolicking children, there is also the open-air apothecary's stall, displaying its strange assortment of dried sea-urchins, alligator heads, earths and herbs, surrounded by dancing masks and a thousand other exciting things.

In this orgy of sunshine and colour and the babble of voices rising over the foliage of the trees, there mingle the sorrows and hopes of a people who have been bypassed by mankind's technological advance. Their lives and desires, so pathetically centred around this place of exchange, are slowly adapting themselves to another focus of their activities. It is less colourful, of less immediate benefit but, in the long run, of even greater significance.

On their way back to the little pier where their quaint dug-out canoes are waiting, they pass a gate with a simple notice nailed over it : "International Territory — United Nations." Behind the gate are the Headquarters of CREFAL (Centro Regional de Educación Fundamental de América Latina), Latin America's first training centre for rural educators, set up by Unesco. From its windows, looking out across the lake, one can see the "laboratory," the villages of the Tarascans.

In less than half-an-hour one is across to the first island. Janitzio is a village of less than 1,500 souls, situated in the middle of the lake. Here a team of Unesco students pays a daily visit. Only a small section of the path leading up to the hill is paved.

Old men with wrinkled faces sit in the sun and repair their fishing-nets. Old and young women spread the tiny fish on the ground to dry them in the sun. Children stretch the nets between branches of the trees, and a small boy is asleep in a big cardboard box, while his mother is mending nets.

The lives of the people of Janitzio are centred around fishing. When the conquering Spaniards subdued the proud Tarascans, the King of Spain sent a bishop to take care of their affairs. Vasco de Quiroga, the man on whom his choice fell, began to organize the people around the lake and to teach them crafts. He chose a different one for each village, and these have been passed on from generation to generation.

Janitzio's people have been living on fishing for centuries, and it is their privilege to take the famed *pescado blanco* or white fish to the Friday market. They do no basket-making or pottery, but, like all the other villages, just stick to their own trade.

It is this strange *status quo*, this centuries-old gentlemen's agreement between the villages of the lake, that provides the basic background to the "laboratory" of 18 villages. To improve the lives of the villagers is possible only by respecting this *status quo* and working within the framework of their traditional occupations. For, to achieve lasting improvements, projects have to be organized and carried out by the inhabitants themselves.

Up, behind the church, there is a tiny plateau and a group of young fishermen are working on it, shovel in hand. Our Unesco team — a Haitian girl and a young man from San Salvador — are greeted like old friends. Instead of the customary siesta, these fishermen are putting in their few hours mixing concrete and spreading it across the little square.

"It will be the finest sports ground in Michoacán," declares Alfonzo Vargas, one of the working team. "It cost 300 pesos... and do you know that everyone in the village has contributed?" he says with

*(Continued on next page)*

# Doing a job for an entire continent

*(Continued from previous page)*

pride, and explains that they have to hurry up because the rest of the road leading up from the pier will also have to be paved by Christmas.

"It's all voluntary work," Vargas says, "we all have only a few hours each day... after all, the lake comes first..." and he looks out over the blue water that for centuries has provided the livelihood of Janitzio.

Meanwhile, the Haitian girl has drifted away and she is discussing with an old woman how the fish could be dried with less effort and in a more hygienic fashion. Vargas and his fellows are in agitated discussion with the young teacher from San Salvador about the price of cement and how a little could be saved to repair the cracked wall of the church.

One of them brings up an old project of publishing a small guide-book to explain to visiting tourists the mural paintings inside the giant Morelos statue on the top of the hill. "From the sales of the booklet we might buy a small canning machine and preserve our fish," one of the boys remarks. The others look sceptical.

"It's up to us," Vargas retorts, "we have to think of the future." And the teacher from San Salvador helps them to calculate the cost and promises to discuss the plan at the Centre.

Next day we go to Ihuatzio, a village on the shore. It is smaller even than Janitzio. The people are agriculturists, and more reserved than the fishermen of Janitzio, who are quite used to seeing visiting strangers admiring their island.

The village has a sleepy air; the wooden planks of the landing jetty are hanging in the water; pigs and dogs roam the neglected streets; and apart from a few children sitting around in the middle of the road and playing marbles on a *scrape*, there is seemingly little interest in our group. But the Mexican specialist in rural education who came with us takes me to a little clearing in front of an empty building, and proudly points to a group of men clearing stones from the ground.

"They are volunteers," he says. "They are preparing the square and repairing the building which is to be their community centre. One day the village co-operative will be directed from here..."

We wade through mud and water and arrive at a modest house where young women stand chatting on the porch. They busy themselves around a young Costa Rican student of the Centre, who shows them how to embroider the belts which they send to the market each Friday. Their conversation shifts to questions of food. The student explains to them how meals can be varied and prepared more hygienically.

"We are getting them to do something about that jetty too," the Mexican specialist says. But I interrupt him: "All this is very little... too slow."

The Mexican's tone, which has been enthusiastic, becomes emphatic. "You can change society by either revolution or evolution," he says. "The first may be quicker and more spectacular — but probably less lasting. In this country we have certainly had enough experience of it. Our way is the painful, slow method of teaching people how they can change their lives. It is not imposed, it is developed... it is slow, but it is lasting."

He pauses, then goes on again. "You could change this village from top to bottom in 24 hours — it has been tried before. But in a few months, in a year, everything would be right back where it was in the past.

"You see, once these people really feel and believe that the changes are necessary, and get together and build their own co-operative or adopt a new method of working because they realize its advantages, Ihuatzio will have taken a lasting step forward.

"And that's exactly why we're here : not to do things for the people, but to help them to do things for themselves. Real rural education must rest on this basic principle... and, by necessity, the results must be slow and gradual."

Results, of course, depend on a number of factors. Some villages may be more aloof and more suspicious of outside interference than others. The personality of teacher-students in the teams that visit the villages is of great importance. There is an inevitable period of "probing." First the students will just walk around trying to understand the problems of "their" village and be ready to offer advice wherever it is asked for.

Sometimes circumstances may favour their work. In one of the villages confidential relationship was quickly established because one of the students was able to offer quick and effective help to combat a violent outbreak of malaria. In some others, like Ihuatzio, it took two months before the villagers began to display any desire to co-operate.

But the more resistance there is to overcome, the more lasting the improvements will be, as they spring from the conviction that the advice and example given have led to self-help and an improvement in living conditions.

I saw proof of that on another of Lake Pátzcuaro's tiny islands—Jaracuaro. The Tarascans of this village are no richer than their neighbours. Yet, when they ferried our team over to their island, they refused to take money for it.

"Not from you, Señor..." said Pascal Corral, secretary of the village council, as he was offered the money by Filiberto Tentori, the popular Mexican teacher-student working in this community. Here the daily arrival of the team is greeted with friendly smiles, with roadside chats about current problems, and with the confidence shown to comrades who are offering a friendly hand.

Jaracuaro is the "sombrero-island," which manufactures wide-brimmed straw-hats. But there is also a little land behind the village where most of the food needed is produced. When we entered Vicente Rendon's house we were greeted with the words: "My house is at your disposal..." He and his assistant were working on their machines, sewing straw-ribbons into a hat. While another young man struggled with the creaking press to flatten the straw, Vicente talked about a power-press.

Now that the village co-operative is in existence and has decided to have an electric power-press, the co-operative is about to embark on its first serious action. With the help of the Pátzcuaro Centre, the Electricity Commission agreed to the village's request. In a matter of weeks, the cables will be sunk into the water across the lake. The poles to carry the wires have already been hauled across the water by a fleet of canoes organized by the villagers, and now everybody is waiting for the day when the light will go on in the church of Jaracuaro.

The basket-ball ground is already in use, and young people meet there every evening. The contaminated old well has been replaced by a new one and the village is planning to buy an electric pump for it.

Only a few days ago, Filiberto was presented with the first issue of the village's wall-journal. The designs and articles had all been made by the villagers, and the teacher's wife had written the main article about what electricity will mean in the villagers' lives. The section on sports was written by the young people themselves.

In next month's issue they intend to launch a campaign for the building of a wood causeway across the water. This would save buying canoes, which are expensive.

Jaracuaro is wide awake and is beginning to take its future in its own hands. On our way back, swaying in the shaky canoe, Filiberto proudly told me : "When I first came here five months ago they looked just as suspicious as the people you have seen in Ihuatzio. When they had an epidemic among their pigs and I told them that they ought to kill and burn the diseased animals, they were furious. Now, however, they understand why they should."

The story is not very different in the other "laboratory" villages. Problems and human reactions vary according to local circumstances. But beyond them all, there is a patient transformation that slowly changes the outlook of the men and women going up to the Pátzcuaro market every Friday morning. Slowly, their own efforts will give them better results. Already communities are beginning to adopt new ways which will make life in them both more rational and more humane.

Behind the transformation stands CREFAL with its educational films, its slides and lectures, its 50 teacher-students from nine different countries, the educational experts, the specialists and technicians and the handful of devoted men who direct the entire operation. The teams, always composed of five specialized pupils (for health, economics, labour problems, basic education and recreation activities) go out to learn while helping the villagers.

I was speaking of results one morning with one of the directors of the Unesco Fundamental Education Centre when he interrupted me impatiently: "Our principal ambition is not to get quick results, though naturally it is satisfying to see results... but our real task is to train these 50 young teachers, and the many others who will come after them, how to tackle these problems of village education... the more difficult the reception they have, the happier I am.

"They are here to learn every trick and every detail of how to penetrate the villages, how to learn their problems, and how best to establish themselves as people whose advice and expert knowledge are accepted and acted upon. That's almost more important to us than to have spectacular results...

"When they go home to their own countries all over Latin America and begin to teach others the art they have learned from hard experience, then we shall know that we have been doing a good job for an entire continent..."

As we were talking, the Centre's large blue bus was driving up the road to take its load of students to the lake. They were beginning another day dedicated to the future of an entire continent.

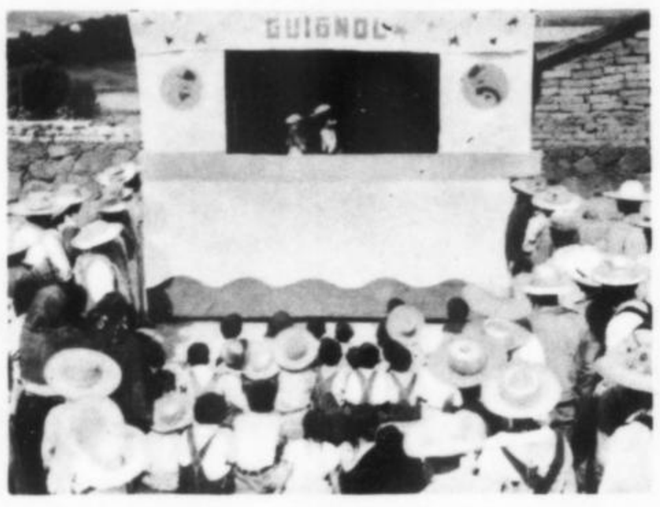
## AT THE CENTRE

An instructor explains the use of the cine-camera.

Discussing future posters in art studio.

Filmstrips are produced to meet local needs.

## ...AND OUTSIDE

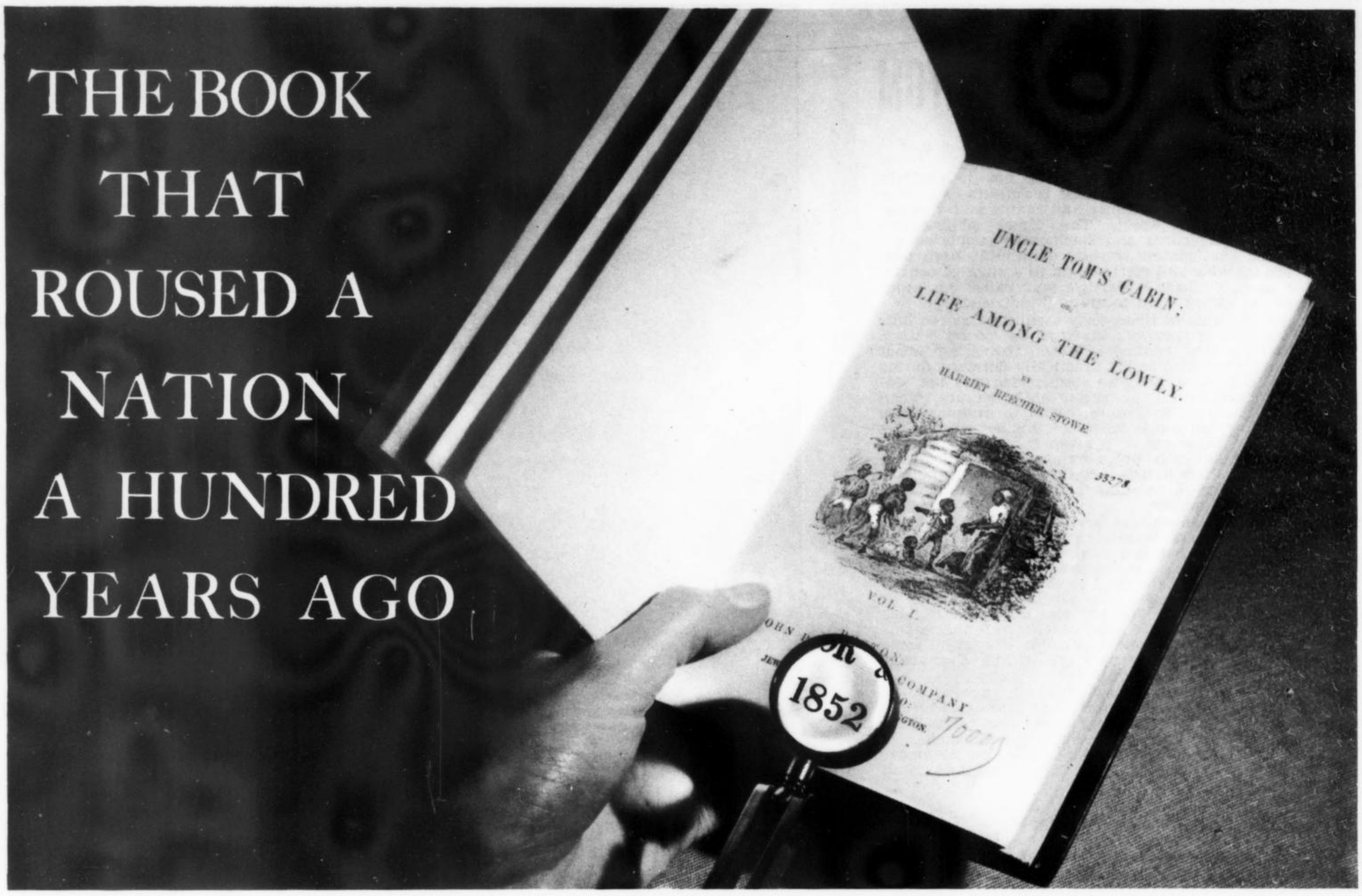



Health education is fun when it's a puppet show.

Tarascan women learn fine points of needlework.

It's easy to enlarge that window, student explains.

# THE BOOK THAT ROUSED A NATION A HUNDRED YEARS AGO




IN 1850, the wife of a Puritan clergyman, Mrs. Harriet Beecher Stowe, was challenged by her sister - in - law, Mrs. Edward Beecher, to "write something that would make this whole nation feel what an accursed thing slavery is." The answer to that challenge was *Uncle Tom's Cabin; or Life Among the Lowly* which appeared serially in the *National Era*, an anti - slavery newspaper of Washington, D.C. in 1851. It was published in book form on March 20, 1852 — one hundred years ago — in two volumes, with a woodcut of a Negro cabin as the frontispiece (*see photo at top of page*).

Although no-one had expected the work to be popular or successful (the Boston publisher who had contracted for the book rights protested that she was making the story too long), ten thousand copies were sold in less than a week and within a year sales in the United States amounted to some 300,000 copies. In England, where the British slave trade had been abolished in 1833, the book swept across the country. Circulation reached a million and a half by the end of the first year in a triumph of pirated editions.

Although hastily written, its drama and emotional ardour gave it wide appeal. It was soon translated into more than 20 languages, and presented countless times on the stage and in the cinema. As late as 1890, sixteen separate companies of actors were taking *Uncle Tom's Cabin* from town to town in the United States, presenting the play in tents, and it was shown on the American stage every year until the 1930's.

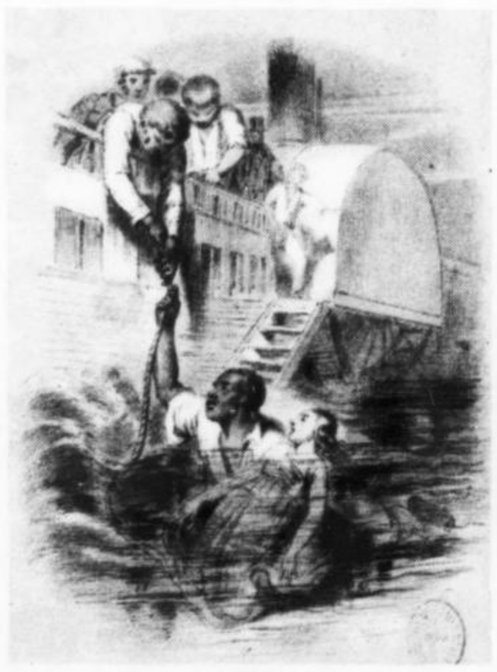
Soon after the book reached Europe in 1852, a French critic, M. John Lemoine, wrote in the *Journal des Débats :* "Here is a little book which in a few hundred pages contains all the elements of a revolution... It will do more for the freeing of the Negroes than all the speeches, all the sermons, or all the treaties and crusades have done up until now... It is perhaps the most profound blow ever delivered against a blasphemous institution— slavery; and this blow has been delivered by a woman."

Few books, indeed, have had a more direct and powerful influence on America— and on the rest of the world — than *Uncle Tom's Cabin*. By its vivid descriptions of Negro suffering and oppression, it stirred up a whirlwind of anti-slavery agitation in the North. More and more Northerners came to believe that Southern masters were generally cruel to their slaves. Although slaves in general were fairly well treated, the North became convinced that the opposite was true. Probably no other book in the history of the United States ever aroused such a storm of anger. It served as one of the important forces in bringing about the Civil War.

Harriet Beecher Stowe had not foreseen the storm of wrath which *Uncle Tom* was to arouse. In the South, slaveholders condemned it as extremely unfair, and her very name was hated. A cousin living in Georgia wrote that she feared receiving letters with her name on the outside envelope. The *Southern Literary Messenger* declared the book a "criminal prostitution of the high functions of the imagination," adding that the author had "placed herself without the pale of kindly treatment at the hands of Southern criticism."

Mrs. Stowe, however, apparently had a fondness for the South. While she hated it for upholding slavery, she portrayed its atmosphere with sympathy. For this the Abolitionists criticized her, affirming that the book showed too many of the favourable aspects of slavery. From all sides, therefore, she was attacked and the accuracy of her facts questioned. Her reply to this criticism was *A Key to Uncle Tom's Cabin*, published in 1853. From the popular point of view this book was a total failure. In 1856, she wrote a second anti-slavery novel, *Dred: A Tale of the Dismal Swamp*. This too failed to achieve any popularity, except in England where 100,000 copies were sold in less than a month. Today, the book is practically unknown.

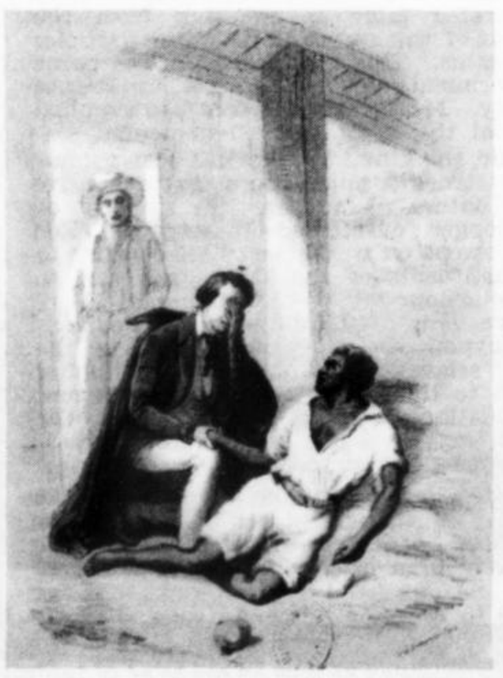
The slavery question which rent the abolitionist North and slave-holding South was, of course, nothing new when Mrs. Stowe's book appeared in 1852. In the 18th century, many Southerners had condemned slavery in principle and tolerated it only as a temporary measure. Washington and Jefferson, both slave-owners, were hostile to slavery, while John Randolph had freed his. Two events occurred, however, which were destined to transform the interests and ideas of the South: the invention of the cotton gin in 1793, which revolutionized the cotton industry and brought with it an enormous influx of slave labour from Africa; and the law of 1808 which stopped further importation of slaves, thereby placing a premium on existing slave labour.



Thus the South came to defend slavery with heated passion as one of the mainstays of its existence. Planters failed to see anything odious about slavery in the same way as the industrialists of the North were later unmoved by the evils of child labour. Apologists of slavery preached the doctrine of "a natural and divine order" asserting "that men should reduce one another to slavery is part of nature in the same way as it is the natural order of things that animals eat one another." One apologist, a Mr. Harper, even went so far as to declare; "It is true that the slave has no hope of improving his lot; but as he owns nothing, he has nothing to lose."

But it was the Fugitive Slave Law of 1850 that really aroused Northerners to the evils of slavery. This law not only gave federal authorities the right to arrest fugitive slaves, but made it a crime to help a Negro to escape. And no proof was needed to make an arrest.

It was this new slave law that set off the spark of intense abolitionist feeling in Harriet Beecher Stowe. Before that, her letters confirm her son's statement that for many years she "was anti-slavery in her sympathies, but she was not a declared abolitionist." Her father, a Calvinist pastor, was one of the links in the "Underground Railroad." His seminary was a hotbed of anti-slavery sentiment; and one of the most extreme advocates of Abolitionism, Theodore D. Weld, was an early student there. For 18 years she lived in Cincinnatti, Ohio. Just across the Ohio River lay slave territory and visits to plantations quickened Harriet Beecher's hatred of slavery. Her husband was also strongly hostile to slavery. Together they later helped many fugitive slaves to escape to safety. Her brother, Edward Beecher, fanned her sentiments on slavery to white heat. From his Boston pulpit he thundered against the Fugitive Slave Law, and it was his wife who wrote to Mrs. Stowe to "write something that would make this whole nation feel what an accursed thing slavery is."



Harriet Beecher Stowe was the first American writer to take the Negro seriously and to conceive a novel with the black man as the hero. Although to some people nowadays *Uncle Tom's Cabin* may seem of little more than historical interest, it nevertheless remains as one of the world's most famous novels. It played a great part in arousing public opinion; it certainly hastened the abolition of slavery.

# THE EVER-RESTLESS ATOM

*by Ira M. Freeman*

THE notion that gross matter is not the uniform, continuous substance that it appears to be goes back to ancient times and man's first speculations about the world. The Greek philosophers Leucippus, Epicurus and Democritus supported the doctrine that matter consists of minute, hard particles, invisible and eternal, and in a state of continual motion. Such a particle was called an atom, from the Greek word meaning " indivisible. "

The thoughts of these early atomists survived only in the famous poem of Lucretius, *De Rerum Natura*, written several centuries later. Theorizing about the nature of matter lay practically dormant during the Middle Ages, and the atomic idea was not seriously revived until the seventeenth century, when Pierre Gassendi, in France, began to examine some of the physical consequences of this hypothesis. By assuming the atoms of a given substance to be all alike and to rush about randomly, colliding frequently in their frenzied, restless movement, he was able to offer a plausible picture of the observed behaviour of matter.

All known substances are either solid, liquid or gaseous. We are familiar with water, not only in its liquid state, but also as a solid (ice) and as a gas (steam or vapour). A true solid has a characteristic crystal form, as manifested by the variety of beautiful geometric shapes shown by natural crystals such as gems and minerals. These forms are but reflections of the regularity of arrangement of the atoms within the crystals, held as though arrayed on some invisible framework, yet capable of vibrating about their appointed positions.

If heat is supplied to a crystal, the excursions of the atoms are increased until they succeed in breaking away from the powerful forces that make them cohere to their neighbours, and the solid melts. It is now a liquid, in which the atoms are no longer constrained to the orderly arrangement of the crystal.

**IN ORDINARY AIR, each particle**

* has a diameter of about 0.00000004 of a centimetre,
* weighs about 0.00000000000000000000005 of a gram,
* moves with an average speed of 50,000 cms. a second,
* collides with its neighbours 5,000,000,000 times a second.

There are 27,000,000,000,000,000,000 particles in each cubic centimetre of air.

Even under ordinary conditions, but especially at higher temperatures, there are some favoured atoms or groups of atoms (called molecules), possessing excess energy which enables them to wrench themselves loose from the attractions of the others and soar away as individuals in the space above the liquid mass. The aggregate of these independent molecules is the vapour—a gas. It is a collection of jostling flying particles, filling the container by their motion. Raising the temperature results in swifter motion and the gas presses more strongly against the walls of its confining vessel ; lowering the temperature has the opposite effect. Only at the absolute zero of temperature would the motion cease altogether (see the *Courier* for October, 1951).

Because in a gas the molecules are free of mutual influences except at the instant of collision, a gas is the simplest state of matter, and so is the best understood. The English scientist Callendar aptly described a gas as "a homogeneous chaos, with that uniformity in the midst of diversity which is characteristic of probability." The branch of mathematics appropriate for treating the behaviour of a swarm of particles is statistics, whose application to gases and more recently to liquids and solids as well have not only led to a rather complete understanding of the structure of matter in the large in terms of matter in the small, but have also succeeded in revealing the magnitudes and characteristics of molecules.

The Swiss scientist Daniel Bernoulli was the first to ascribe the pressure of a gas to the impacts of its molecules—individually feeble and erratic, but producing a steady and considerable effect in the aggregate. Over a century later, Waterston and Joule improved his calculations and established the first mathematical relationship involving molecular magnitudes. In rapid succession the mathematical attack was continued by Kronig and Clausius in Germany and by Maxwell in Britain, so that by the middle of the nineteenth century the so-called kinetic theory of gases was well founded.

When the theory was compared with experimental observations on gross matter, the results were astonishing. Molecules were revealed as entities a hundred-millionth of a centimetre in size and weighing but a few billionths of a billionth of a gram ; they were shown to be moving with speeds of the order of a kilometre per second. This knowledge and much more has been obtained in spite of the impossibility of seeing or handling individual atoms or molecules. As early as 1827 an English botanist, Robert Brown, observed that grains of pollen suspended in water executed a ceaseless trembling motion, and this was correctly interpreted later as resulting from the irregular impacts of the surrounding water particles on the pollen grains. This interpretation was borne out by the experiments of Jean Perrin in France early this century. Meanwhile, Einstein had supplied the mathematical theory of this phenomenon.

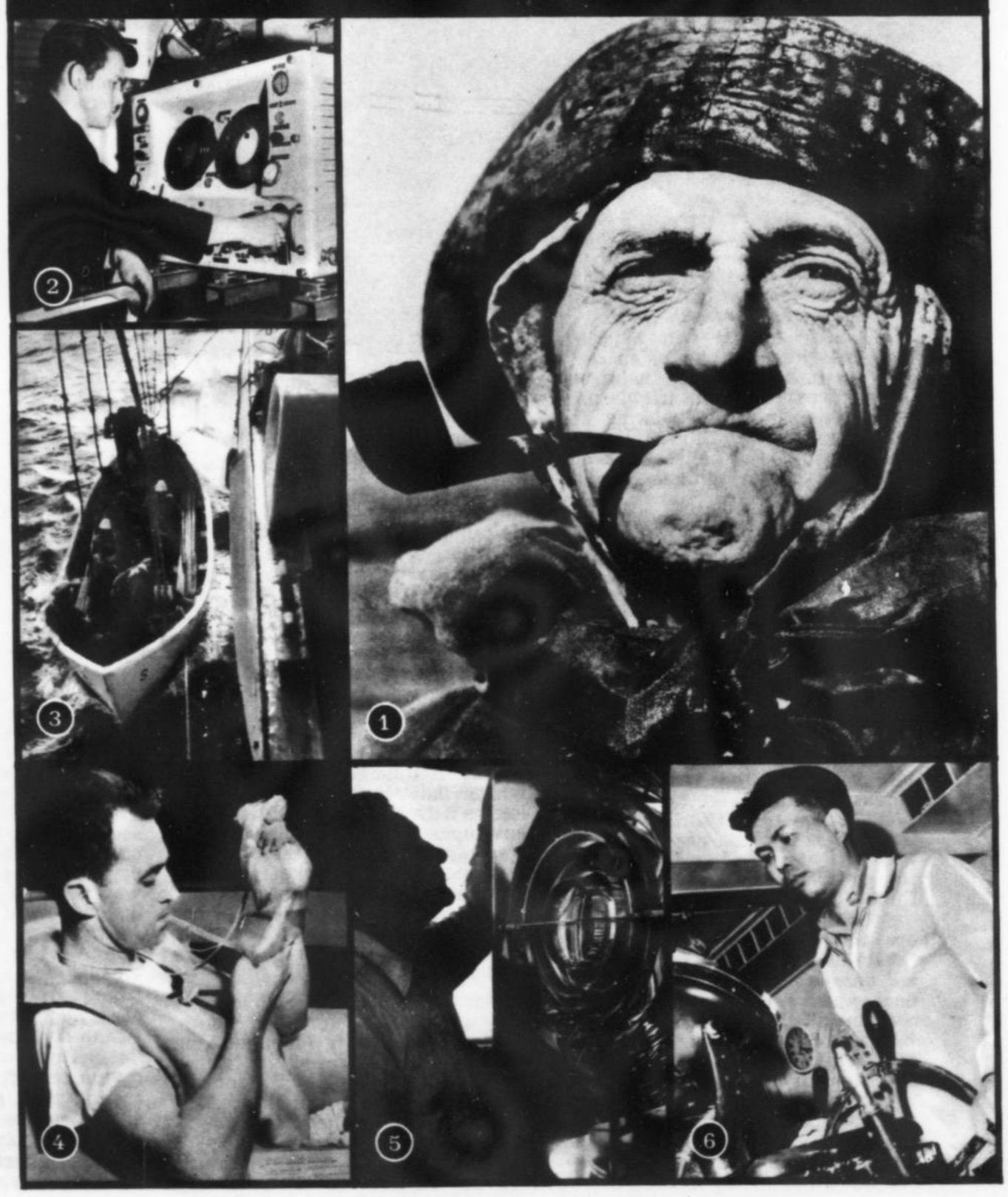
Since that time, the kinetic theory has been rounded out to give science a much more comprehensive picture of the nature of matter. The reality of atoms is no longer questioned—indeed, the tide of research has swept on in the last half-century to explore the constituents of the atom itself and to study their behaviour (see "Fundamental Particles—What Are They ?" In July-August *Courier*).

A scientific hypothesis is valuable only to the extent that it relates the unknown to simplier experiences, and to the extent that it suggests new lines of investigation. Judged in this light, the kinetic theory of matter is one of the most successful scientific theories ever proposed.

*If you are interested in reading more about the Kinetic Theory of Matter, write to the Division for the Popularization of Science, Unesco, 19 Avenue Kléber, Paris, XVIe for a brief bibliography sent free of charge.*

# SAFETY ON THE HIGH SEAS

Man of the sea (1) today benefits from increased international co-operation and modern techniques. Eyes of radar (2) on U.N. weather ships in mid-ocean trace course of ship or plane on twin screens. As soon as distress signals are intercepted, weather ship speeds to rescue (3). Research has produced new life-saving devices for shipwrecks on high seas such as this plastic device (4) which converts sea water into drinking water. Every night, 37,000 lighthouses pierce darkness ; optic signals from powerful lamps (5) can be understood by sailors (6) everywhere approaching foreign ports. (United Nations photos.)



AFIELD as old as man's spirit of adventure and enterprise is now coming within the scope of United Nations activities, as the seafaring nations take new steps for joint action to develop and improve measures for bringing maritime hazards under control.

Two international conferences have prepared the ground. The U.N. Maritime Conference, which met at Geneva in 1948, established IMCO (the Inter-Governmental Maritime Consultative Organization), which will join the U.N. Specialized Agencies. This organization is still in the early stages of formation. As soon as it comes formally into being, its task will be to promote higher standards of maritime safety and efficiency of navigation. Another important step was a Sea Safety Conference held in London the same year. It prepared and opened for acceptance the International Convention for the Safety of Life at Sea, 1948, which will replace the old convention of 1929.

### 37,000 lighthouses

MARITIME co-operation is not new. Faced with the perils of the sea, man early understood the need for common action. Beacons sprang up all over the world to mark perilous waters, shoals and reefs, and today the globe is dotted with some 37,000 lighthouses. Between the ancient Lighthouse of Alexandria, one of the seven wonders of the world, and the helicopter patrol of today, lies a story of practical and effective co-operation among nations to establish common methods for guiding and guarding ships wherever they sail. Lifeboat service, maintenance of buoys, weather charts and international signalling codes are only a few examples. A typical measure is an international agreement of 1930 establishing the International Load Line, designed to prevent overloading of vessels with cargo and passengers. Similarly, rules were laid down for collision prevention; and since the Titanic disaster in 1912, a regular iceberg patrol has been operated by the U.S. Navy for the benefit of all nations. Now it is financially supported on an international basis.

Although modern science has placed at the seafarer's disposal new means of making shipping safe, nature still takes a heavy toll of man's life and property. For instance, in 1946, the first year of peace, as many as 179 vessels were lost on the high seas, representing a gross tonnage of 370,000. This indicates clearly that, due to the vast increase in sea and air traffic, the need for international co-operation is as great as ever.

### Weather-rescue ships

TODAY, under direct or indirect U. N. encouragement, new progress is being made in maritime safety. An important part is played by a patrol network of weather-rescue ships established recently along the main traffic routes in the North Atlantic. These vessels, equipped with the latest scientific devices, make periodic observations of weather conditions and relay their information to shore stations for incorporation in weather forecasts. At the same time, they supply weather data to ships and transoceanic planes, and keep constant watch for any craft in distress. The scheme, sponsored by the International Civil Aviation Organization of the United Nations, is operated on an international basis.

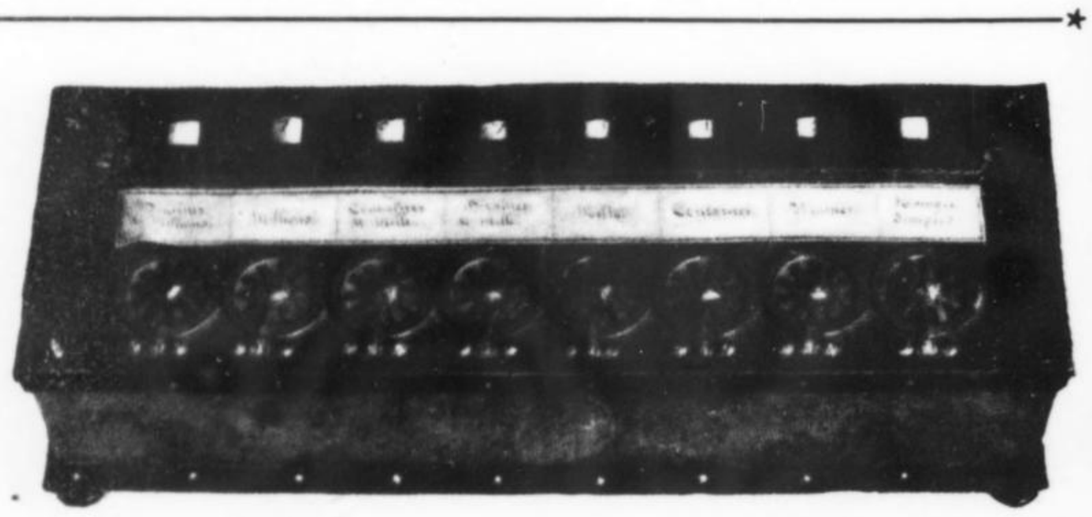
When the Safety of Life at Sea Convention comes into force, and its provisions embodying the latest scientific advances are generally accepted and put into practice, the men who sail the seas, both passenger and sailor, will greatly benefit from this new agreement among nations.

FIRES ABOARD SHIP have long been the scourge of the seafarer. These strange-looking asbestos suits — a product of research into safety at sea — enable many a fire-fighter to save life as well as valuable cargoes. (U.N. Photo.)

# THE WORK OF A CENTURY — IN A FEW MINUTES

## Calculating machines, and the revolution in science which they are helping to bring about

*by Dr. S. LILLEY*
University of Birmingham,
Department of Extra-Mural Studies



WHAT A CONTRAST between the first calculating machine of Pascal in 1642 and the giant computing marvels of today (above) known as the IBM Selective Sequence Electronic Calculator. Ask a number such as 16,457,895,753,902 and multiply it by itself. It can add or subtract even larger numbers 3,500 times a second.

"HOW much...?" "How many...?" A surprisingly large number of important questions of modern life begin with those words. How many skilled mechanics can India rely on for building much-needed machinery? How much will a sixpence-in-the-pound increase in income tax yield? How much energy can you get from a pound of uranium 235?

Some of the most important questions of all do not, at first sight, take this form:—For instance, can India avoid a famine in 1956? But to answer it, we have to ask: **How many** mouths will there be to feed? **How much** food can India's own agriculture produce? **How much** of her manufactures can she export to make up for the deficiency?... and so back to that first question about skilled mechanics. Without "How much?" and "How many?" we should not make our modern world work.

In science, more than anything else, these two questions are of vital importance. There is scarcely any major scientific problem—from the nature of the universe to the workings of the endocrine glands, from the utilisation of atomic energy to the assessment of an adequate diet—whose solution does not depend essentially on counting and measuring, and then making calculations.

Making calculations—that is the important point. To answer "How much?" and "How many?" it is usually not good enough to measure, weigh and count. We must also do immense calculations to deduce facts about a whole population in 1956 from a few thousand answers to a sample survey in 1951, or to calculate the energy obtainable from a uranium pile on the basis of data produced from small-scale experiments with cyclotrons.

It is with this process of calculation and the ingenuity that has gone into making machines to do it for us that this article is concerned.

"How much?" and "How many?" have not always been so important. They are characteristically modern questions. Until some 350 or 400 years ago they mattered rather little. The small peasant communities that made up most of the world till then could get along very well with a minimum of calculation.

Even the cities of Greece or the Empire of Rome needed less in the way of statistics than a town council does today. And in science before the 16th century, the characteristic questions were not "How much?" and "How many?" but "What sort?" and "Why?"

Calculation played so small a part in ancient life that most people were content with cumbersome systems of arithmetical notation, of which Roman numerals is only one of the worst examples. It is hard enough to add with these old systems; it is almost impossible to multiply. And so calculations were commonly done with an abacus — by moving beads on wires or counters on a marked board.

In a sense, the abacus was the first calculating machine. But it does not count for much in our story. Though it can be extremely quick, it is less efficient than calculation on paper. And the first step towards our modern arithmetical world was the development, mostly in the later Middle Ages, of our familiar methods of adding, subtracting, multiplying and dividing, so that calculations could conveniently be done on paper without the help of an abacus.

Towards the end of the 16th century the modern world was fast emerging. The local, almost self-sufficient units of feudalism were being bound together to form truly national states — which needed statistics of taxability and military resources. Large-scale commerce was growing; custom or guild rules no longer served to guide the businessman, but had to be replaced by extensive and accurate calculations of cost, selling price and profit.

Surveying, mining engineering, military engineering, and a host of other techniques were coming to rely more and more on mathematical accuracy. Science was taking on its characteristically modern form with its emphasis on "How much" and "How many." Men grew very interested in saving time and trouble in their calculations. In 1585 the Dutchman Simon Stevin published his little book advocating the use of decimal fractions and so inaugurated a new era in arithmetic. And in 1614 John Napier of Scotland made logarithms known to the world.

In this atmosphere it could not be long before some genius or other would invent a calculating machine. In fact two of the really outstanding scientists of the 17th century — Blaise Pascal and G.W. Leibnitz — besides numerous minor men of science, devised such machines. Pascal's father, as a Government superintendent in the French *département* of Haute-Normandie, had to check an enormous number of accounts, and it was to aid him in this work that his 18-year old son designed the first machine for adding and subtracting, and constructed it in 1642 with the aid of a Rouen blacksmith.

Several other similar machines were invented. In 1694, Leibniz produced the first machine that could do all the ordinary processes of arithmetic: add, subtract, multiply and divide.

During the 18th century many more inventors tried their hands at calculating machines, and before 1800 they had created practically all the devices that go to make up a modern "general purposes" (adding, subtracting, multiplying and dividing) machine.

But none of these instruments was a practical success. Some would work well enough when handled carefully by experts, but the engineering technique was not available to turn out calculators good enough and reliable enough for day-to-day use.

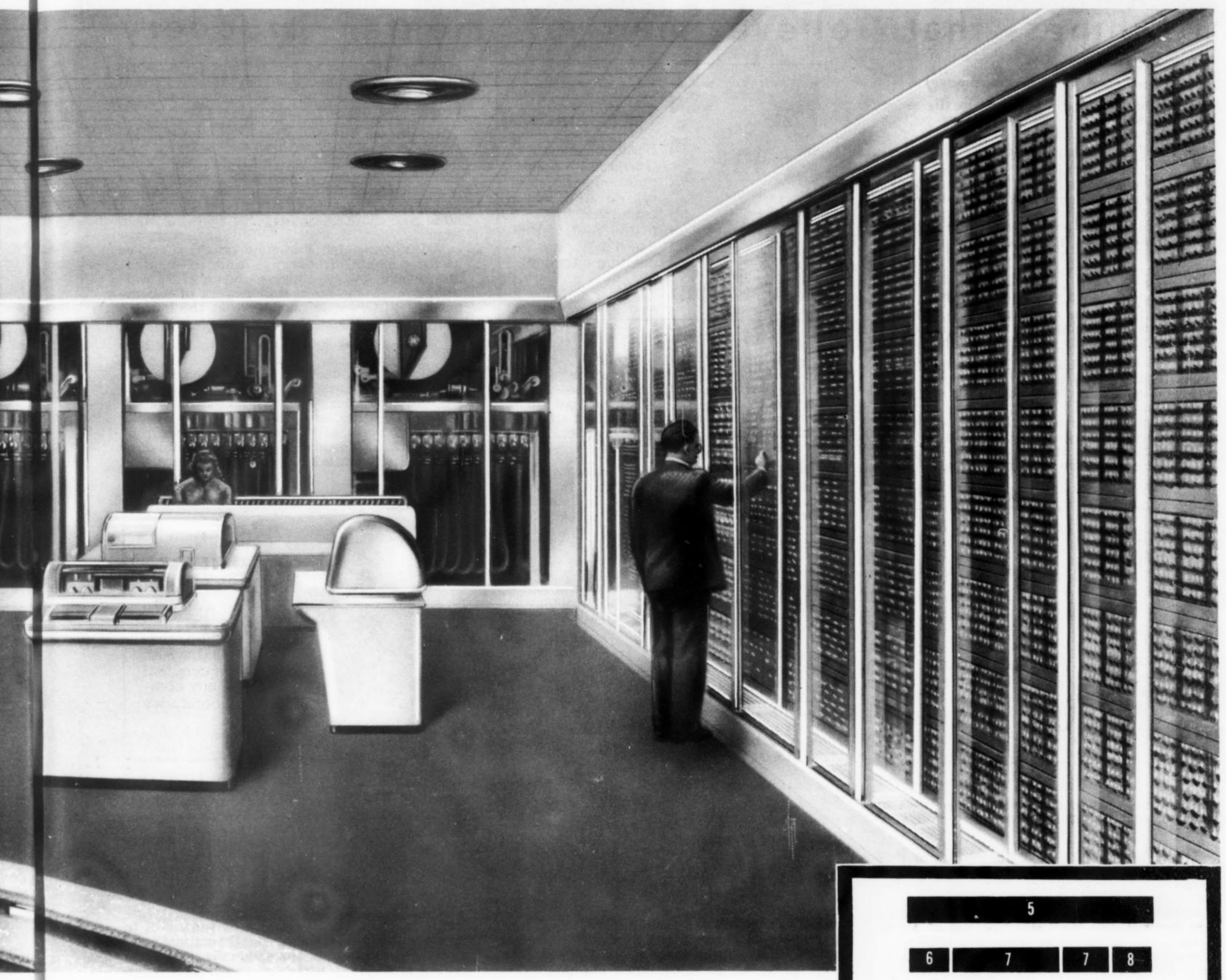
However, with the gradual improvement of engineering techniques, practical machines came during the 19th century. The first was that of the Frenchman Thomas de Colmar, which appeared in 1820.

In 1892 came the best known of all calculating machines, the Brunsviga, which was such a success that some 20,000 were sold within 20 years. By now the general purposes machine had reached the end of its basic evolution — though many improvements have been added since, the most important being the electrical drive, to relieve the computer of the labour of churning away at a handle.

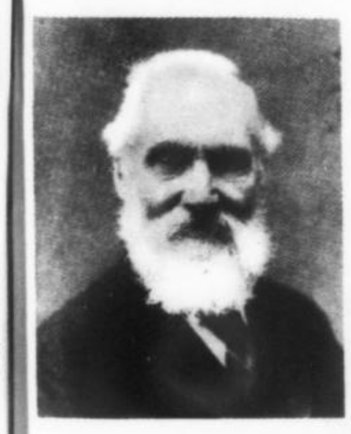
The machines we have so far been describing are called "digital machines," because they work with

**BLAISE PASCAL**

At the age of 18, he became the first man to make a mathematical calculation by mechanical means with his invention of the original "Arithmetical machine."



ulatinachine (left) invented by vels oday. Mammoth machine e Elecic Calculator, can select oly it self fifty times a second. 00 tim second. It can multiply numbers, store the results in its mechanical memory and then feed them back into a problem in a week or in a thousandth of a second. Built in New York in 1948 for $ 750,000, it was first electronic calculator for pure scientific research in the physical and social sciences and education. Newest electronic marvel in U.S. is Whirlwind I, built last December for Massachusetts Institute of Technology.



**LORD KELVIN**

helped prepare the way for development of modern computing machines with his plan for applying mechanical techniques to complex mathematical problems.

the actual digits with which numbers are written. The later 19th and especially the 20th century have also witnessed the development of a wide variety of machines of a different class — "analogue machines," as they are called.

The basic idea behind all these is very simple. The behaviour of any machine can be represented by a set of mathematical equations and their solution. Conversely, given a set of mathematical equations, one can construct a machine whose behaviour would be represented by them; if one, then, sets the machine working and observes the motions of its various parts, one has the solution of the equations. A speedometer, for example, is an analogue machine which calculates speed from the relation between distance travelled and time (mathematically, it differentiates).

A very important class of mathematical problem depends for its solution on the reverse of this process (integration). For instance, if you know the relations between the rates at which various quantities are changing (differential equations), and their starting value, where will they get to in a given time? Or, to give an easier example : given the motorist's speed at every point, how far will he go in an hour?

As early as 1876 Lord Kelvin sketched a plan for a "differential analyser" —an analogue machine for solving problems of this type. However, he was not able to overcome the mechanical problems involved, and the development of the differential analyser had to wait till 1931, when Dr. Vannevar Bush hit on a very simple way of dealing with the difficulties. Since then differential analysers have been in constant use at dozens of computing laboratories, while many other types of analogue machines have been developed.

Analogue machines have one great advantage over the digital machines we described earlier — they will solve a complete problem at one fell swoop, whereas the digital machine will only do elementary additions, subtractions, multiplications and divisions, and the computer must arrange to combine thousands of these elementary steps to solve the complete problem.

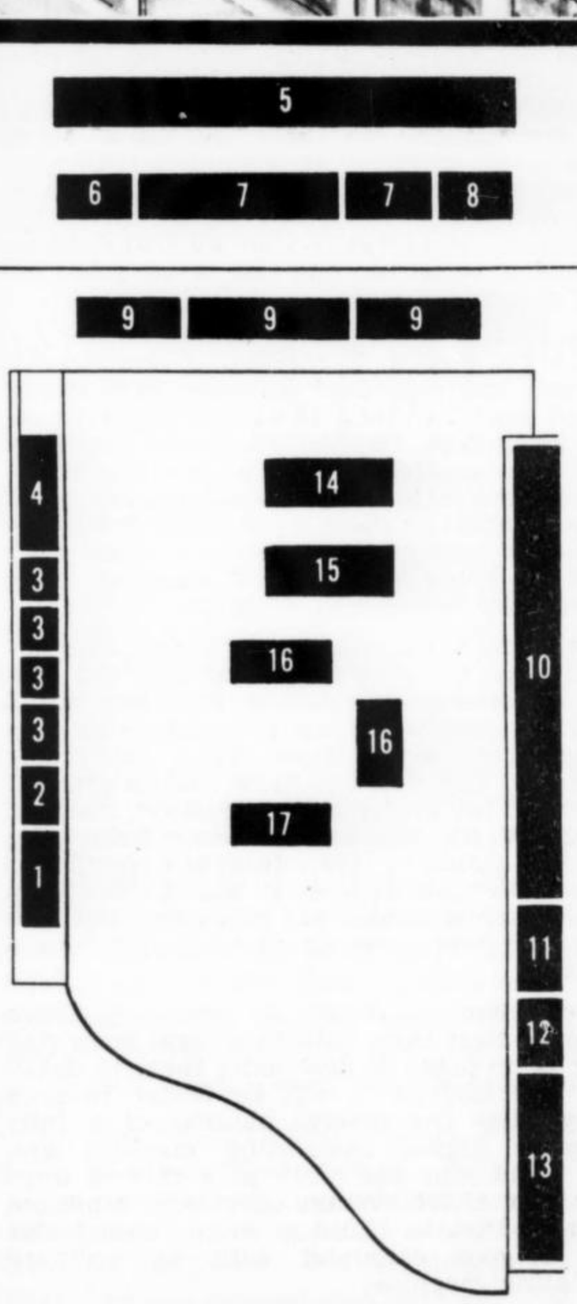
Against that, analogue machines have several disadvantages. Their accuracy tends to be rather low, and they are not flexible—each machine will solve one type of problem only, whereas the computer and digital machine between them can solve any problem, if given time.

Would it be possible to make a machine with the advantages of both—a machine that would solve complete problems without the minute-to-minute guidance of a computer as the analogue machines do, but which will tackle any problem and give results to any desirable accuracy? The answer is Yes.

In the last few years, remarkable machines (of the digital type) with just these powers have been built and put into use. One starts by feeding the machine with a list of instructions and a few initial numbers, and then it gets on with the calculations, adding this pair of numbers, dividing that pair, storing results in a "memory," picking out of the store the numbers it wants for the next step —and so on until the whole complex calculation is finished without any human help.

This is not quite the miracle that it seems at first sight. The duties of a computer using an ordinary digital machine to solve a typical problem can be reduced to a series of instructions which read: "At such-and-such a stage, take the two numbers that are written in such-and-such places in the first column on the paper before you, add them (or subtract, multiply or divide), and write the answer in such-and-such a place in the second column." There may be a few dozen of these instructions — and then will come the order "Repeat

*(Continued on next page)*




**INDEX OF CALCULATOR FLOOR PLAN**

The machine is housed in a specially-designed room. Visitors see only the panels, arranged along three walls of a room 60 feet by 20 feet. Out of sight are complex maze of wiring and apparatus through which pass the electric currents that carry numbers and instructions from circuit to circuit. Equipment in 5, 6, 7, 8, of diagram is located behind rear wall, and is not shown in photo above

**1. Card reading tubes. — 2. sequence tubes. — 3. sequence relays. — 4. table look-up. — 5. relay memory. 6. metres. — 7. control relays. — 8. power distribution. 9. tape memory. — 10. arithmetical unit. — 11. pulse generator. — 12. sequence interlocks. — 13. electronic memory. — 14. console. — 15. printers. — 16. card punches. — 17. card readers.**

# Machines that relieve man of mental drudgery

*(Continued from previous page)*

all this, but using the numbers in the second column," and so on. Obviously a process like this can be mechanised.

The machine will have to have units which will add, subtract, multiply or divide any two numbers supplied to them; it will have to have a "memory" in which it can store the results of calculations until they are wanted again; and it will have to have some means of receiving instructions about the routine it is to follow and of transmitting these instructions to its various parts. It needs a few other elements too, which we need not bother about now. The point is that each of these units is simple in itself and the only complication arises in connecting them together to make one very complex and highly integrated organism.

In 1833 Charles Babbage, a Cambridge mathematician, proposed the construction of a machine on just these lines. His plans included in principle practically every device that is used by the modern machines, but he never succeeded in putting them into practice. It is probable that such a machine built entirely in mechanical terms—of gears, levers

**CHARLES BABBAGE**

The British mathematician who, in 1833, designed a mechanical calculating machine which included almost every device that is now in use.

and the like—would have been unworkable in practice, and no other form was possible in the 19th century.

But in the 20th century we have two new types of devices which alter the picture completely—electro-mechanical relays (in everyday use in automatic telephone exchanges) and electronic devices such as radio valves, photo cells and cathode ray tubes. By using these, instead of mechanical elements like gear wheels, practical problems become manageable, and in addition much higher speeds are obtainable. Machines that do all that Babbage planned have within the last seven years become almost common.

The first of these giant calculators, the Automatic Sequence Controlled Calculator at Harvard, brain-child of Professor H.H. Aiken, started work in 1944. It was an electro-magnetic relay type. By the standards that have since been reached it was a slow machine—taking about a third of a second to add two 23-figure numbers or about six seconds to multiply them—yet even at those speeds it could work about 100 times faster than a computer using an ordinary calculating machine.

The Harvard machine was of momentous importance as the first proof that the idea of a fully automatic calculating machine would work, but the future lay not with relay machines, but with those using electronic elements. The first of these, the Electronic Numerical Integrator and Calculator, designed by John W. Mauchly and J. Presper Eckert, Jr., went into action in 1946. Intended specifically for ballistic calculations, it was limited to a rather narrow range of problems, but the speed had now gone up to 5,000 additions a second.

Since then a dozen or more of these machines have been built in several countries. There is no point in describing them in detail here, and instead it will be better to note briefly what the general abilities of a fully automatic digital calculating machine are. Such a machine can work at a rate of anything from 15,000 average operations a minute upwards—that is, 10,000 or more times faster than a good computer with an ordinary calculating machine.

Given appropriate instructions at the beginning of a run, it can carry out a long series of calculations without further human intervention, and so solve in minutes or hours mathematical problems that would have needed years with earlier methods. Though most of the applications have been mathematical, these machines are by no means confined to mathematics—they can deal with any type of information that can be precisely stated, and deduce its logical consequences.

These calculating giants open up vast new possibilities for humanity. There are very many scientific problems—in such fields as aerodynamics and nuclear physics—in which the theoretician can write down a set of equations and say "Solve these equations and your scientific problem is solved." But in

**H. H. AIKEN**

Head of Harvard University Computation Laboratory, he has been called the "father" of the first of the world's great calculating machines

many cases, the process of solution would be so long that with the older methods it could not be carried out in a lifetime, and so experiments—often costly ones—had to be done instead. Now the speed of the new machines enables us to get practical results from the theory.

Again, in using X-ray crystallography to find out how the atoms are arranged in various solids, a process of trial and error is involved. If the scientist can make certain initial guesses correctly, then the data on the X-ray photographs can be used to calculate the positions of the atoms. But there are often so many choices for the first guess that the solution is in practice beyond us; the crystallographer usually confines himself to cases in which some other sort of evidence gives a strong hint on how to start.

Now, an electronic calculator could be set to try out all the possibilities one after another and to stop and give a signal when it finds the right one. In this way it could run through many thousands of guesses in a day, and give answers in cases which previously could not be tackled. In these and many other ways the new machines should help enormously to accelerate scientific advance, and particularly to facilitate the application of theory to practice.

There will probably be a comparable revolution in the handling of social and economic statistics. One of these machines (on a larger scale than the present ones) could be fed with all the available information about the economy of a country, and then in a few hours it would tell us what would be the effect of increasing a particular tax or introducing new machinery to cheapen the production of steel screws, taking into account all the complex ways in which such a simple change would react on all parts of the economy. All sorts of economic problems which are at present tackled by hit-or-miss methods would be brought within the sphere of reason.

But to see the full long-term implications of these machines we need to set them in a broader historical perspective. For some 6,000 years or so — ever since the first cart was harnessed to an ox or the first sailing ship launched — men have been developing more and more machinery for relieving them from physical drudgery. But until very recently no machine has done much to relieve us from mental drudgery — and, let us make no mistake, the "brainwork" of an office routine or even the more skilled work of a computer is just as much drudgery as the manual work of a navvy.

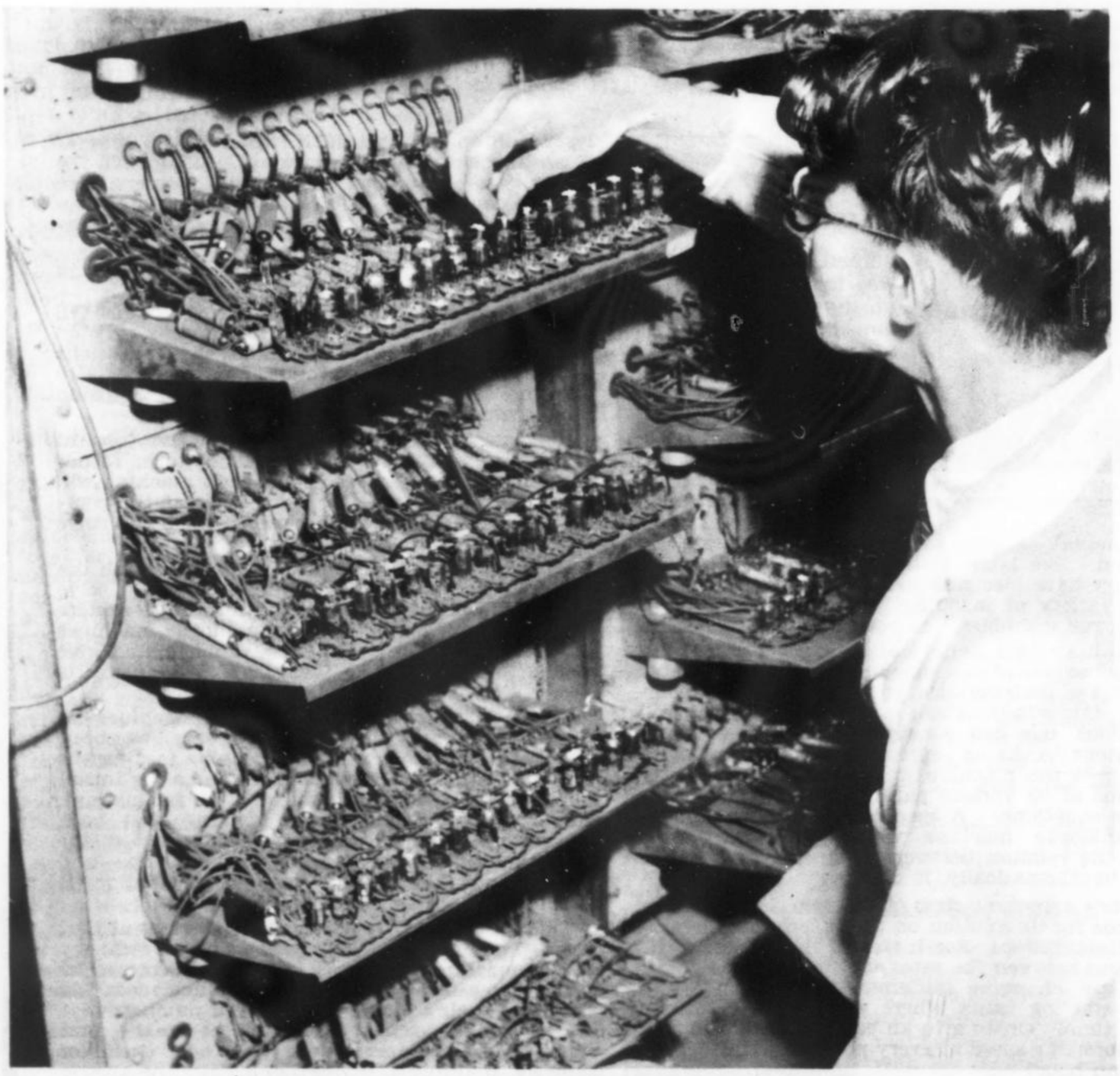
Now machines are beginning to take over our brainwork too — only our second-class brainwork, of course, the parts we can reduce to a routine, not the creative effort of the painter, research scientist, poet or philosopher. As this new trend develops, we can foresee a world in which all uncreative routine work, all drudgery, whether manual or mental, has been taken over by machines, and

**VANNEVAR BUSH**

Succeeded in building the first differential analyser in 1931, which is now in constant use in many computing laboratories

men and women are liberated to develop to the highest degree their creative faculties.

To end on a more sober note, it is necessary to say that the development of these calculating monsters does not mean that the earlier types of calculating machines will become useless. One does not use a steam-hammer to crack nuts (although it will do so). And similarly there will be plenty of work still to be done by our humbler mathematical servants, the Brunsviga, the slide-rule, the differential analyser — and even pencil and paper.



ELECTRONIC NIGHTMARE: With more than 12,000 electronic tubes built into modern calculators, failures are inevitable. That is why engineers are on permanent duty, ready to locate faulty tubes or connections. Sometimes they can be found and replaced in a few minutes. Sometimes it takes days to track down the failure among the 21,000 electric relays and 40,000 connections inside the calculator.

A DOUBLE CHECK: This modern calculator is, in fact, two calculators, identical twins, each operating simultaneously yet independently, each noting the results of the other. A disparity in results immediately causes both to stop working. The printers (foreground) recording at the rate of 24,000 digits a minute, give a running account of the results produced, thus enabling scientists to follow progress of a calculation and modify their programme in the light of results obtained.

# THE 'MIRACLE' ON 57th STREET

## *A day in a giant computing laboratory*

*by Dr. Gerald WENDT*

AMONG the luxurious windows of New York's 57th Street, displaying fine furs, expensive fashions and valuable paintings, is a store-front that stops every passer-by. It is a broad glass wall that permits an impressive view of a giant electronic calculator at work. It shows a high and spacious hall with its three other walls solidly covered with row upon row of glowing vacuum tubes and tiny lights flashing in swift succession.

It seems a vision of some other and superhuman world. This calculator, this machine that "thinks" with lightning speed and remembers endless numbers and equations, dwarfs the few men that sit at desks beside it as if they were but pigmy servants of its higher intelligence.

Timidly one steps into the hall and hears at once the steady confused chatter of relays and switches, sounding as if a thousand telegraph keys were racing to spell out endless messages. One's first impulse is to retreat and be lost again among the ordinary human beings out there in the street.

But no; a charming young lady steps from the mathematical altar with a welcoming smile and bids you enter. She is hostess for the "thinking machine," and radiantly human. But she is a mathematician too, and offers to guide you and explain its operation. Both mathematics and mathematicians have changed since I struggled with them in school. Improved, I should say.

She tells me that the great calculator has just finished a task that has occupied it for many months of day-and-night operation. It was a calculation which by ordinary methods would have taken many men countless centuries—and therefore would never have been attempted. She shows me the result: a closely printed book of 327 pages, filled with figures that give the correct locations in the heavens of each of the five outer planets—Jupiter, Saturn, Neptune, Uranus and Pluto—at 40-day intervals for a period of 407 years, from the years 1653 to 2060—more than a century into the future.

The book itself contains 1,500,000 numbers, many of them in ten digits. But these are only the final result of more than 150,000,000 figures used in the calculation and temporarily remembered by the calculator. The operation involved over 5,000,000 multiplications and divisions, and more than 7,000,000 separate additions and subtractions of large numbers.

This is an inconceivable number of operations in a short time. But the operations themselves are simple. Even the ancient abacus can add and subtract; and multiplication is merely repeated additions. The most complicated mathematical calculations can be reduced to these simple operations. And there I found the secret of the success of this great calculator which has neither magic nor intelligence.

Its secret is speed. Electric impulses pass through it with the speed of light and they can be added one upon another with the speed of lightning. Actually, additions or subtractions of numbers with 19 digits each can be done at the rate of 3,500 per second. Numbers with 14 digits can be multiplied at the rate of 50 per second and divided at 20 per second.

Only in its speed is it superhuman. And that speed is made possible only by the electronic engineers who built into it 12,500 electronic tubes, 21,400 electric relays and 40,000 connections that can be made, changed or broken by electric wires and plugs. All this is big and complicated, but not superhuman.

In one other respect it does better than man. It can remember more. Figures obtained in one part of a calculation are retained until they can be used in a later part. Or they can be so recorded (on punched cards) that they are remembered forever. But that, too, is old. Any record put on paper is remembered there as long as the paper lasts.

What is new is the vast capacity of this electronic memory. No less than 400,000 separate digits can be stored in the "memory" of the calculator, ready for instant use. The machine has colossal memory and incredible speed in arithmetical operations.

But it cannot think. Every operation must be prescribed for it by the mathematicians who analyze the problem into its parts, supply the necessary data and instruct the machine

*(Continued on next page)*

# A mathematical error : The 'Miracle' stops dead

*(Continued from previous page)*

what to calculate and in what order. Far from being the servants of the electronic giant, they are the masters whose thoughts it obeys. It can do only what they order.

I saw them sitting quietly at the desk, two young mathematicians and two engineers, as the calculator went on and on with flashing light and chattering relays, through dozens or thousands of operations each second. I thought of the months of inaction ahead for them. But suddenly there was dead silence and the lights stopped blinking. Instantly all four men leaped from their chairs to various parts of the calculator. The machine had made an error, detected it, and stopped dead.

There must be no error, so every single operation is done in duplicate. Indeed, the calculator is two calculators, identical twins, each operating independently, doing each operation at the same moment that the other does, and each noting the results the other gets. For hundreds of thousands of steps the results are identical. The instant they are not, everything stops.

Then the mathematicians get busy to discover in which operation the error occurred; the engineers must find the tubes or relays that were involved in that operation and repair or replace them. With more than 12,000 electronic tubes, failures are inevitable, for no tube is perfect and none lasts for ever. An average of four tubes fail each day. Sometimes they can be replaced in a few minutes. Sometimes it takes days to locate the faulty tube or connection.

Then part of the calculation is repeated and the steady hum and flicker of the calculation resumes, without error—but only until the next tube burns out. So a team of four mathematicians and engineers is on duty at all times, 12 men for the three daily shifts.

They are, however, only part of the staff that is required to keep the calculator at work. Three more men are engineers for the air-conditioning that keeps an even temperature for the calculator. The thousands of tubes require no less than 180 kilowatts of electric power for their operation and all this power becomes heat in the tubes, wires and relays. So the calculator stands in a stream of cool air behind a glass wall. The electric refrigeration equals the melting of more than two tons of ice per hour.

But there is more staff. There are the two attractive guides. There are specialists preparing instructions for the operation of the machine, days and weeks into the future. There are the mathematicians who spend weeks studying the next problem that the machine is to solve, dividing it into its parts, indicating the changes in circuits and programme that will be required.

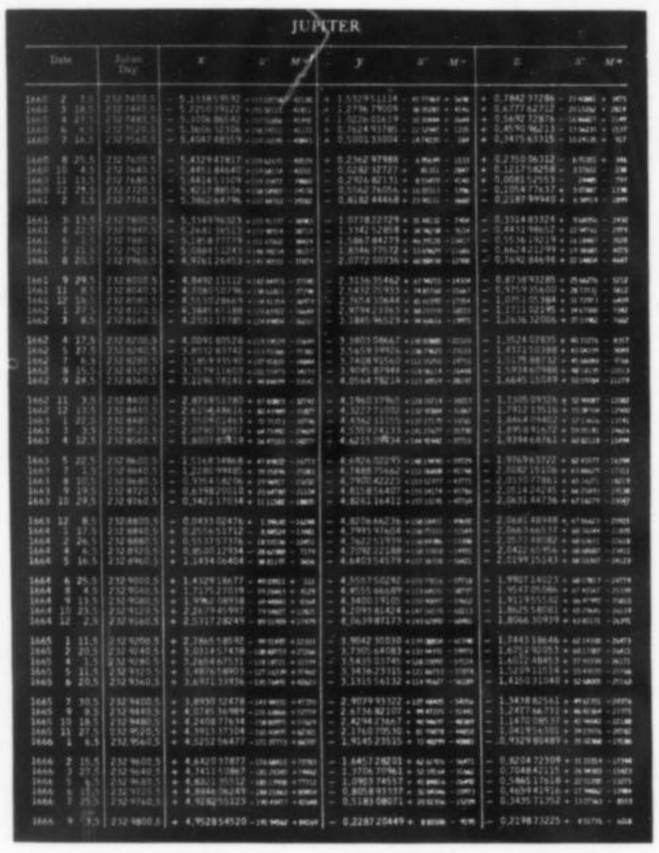
All in all it takes 30 people to keep the machine going. It is not surprising that the cost of its operations is about $300 an hour.

Who can afford such a cost? There are a few industrial and engineering corporations who have rented the use of the calculator for short periods. But for the most part it works for pure science. It is a unit of the Watson Scientific Computing Laboratory, operated jointly by Columbia University and the Department of Pure Science of the International Business Machines Corporation. Under their management, the giant calculator is available without cost to scientists under three conditions:

1. The problem must be of general interest to science;
2. The results must be published and made available to all;
3. The scientist or laboratory that wishes to use it must have insufficient funds to pay for its use.

The Watson Scientific Computing Laboratory occupies an entire building at Columbia University. At the University are other, smaller and more specialized computing machines which may solve smaller or more special problems. The entire research staff of 27 experts, under the direction of Dr. Wallace J. Eckert, Professor of Celestial Mechanics, is engaged in the analysis of future mathematical problems for the computers to solve, in the training of operators for the machines, and in the design of newer and still swifter calculators. Here, if anywhere, are the superhuman brains, for here the giant calculator on 57th Street was conceived and designed. Though colossal and impressive, it is only the product of the brainwork and vision of this group of modest, hardworking men.

## AN "ASTRONOMICAL" CALCULATION




It would have taken human mathematicians many centuries to calculate the exact location in the heavens of the planet Jupiter at 40-day intervals from 1653 to 2060. The giant IBM electronic calculator did the job in about two months. Page (above) shows only small part of awe-inspiring figures produced.

# FIRST INTERNATIONAL COMPUTATION CENTRE WILL OPEN THIS YEAR

THE first international laboratory of the United Nations will open in Italy this year. Behind this news is a heartening story of co-operation among countries of Europe, Asia, Africa and South America who have pooled their resources to make available to all what none of them could manage by itself. That first laboratory is an International Computation Centre which will be established in Rome to house the enormous, intricate machines that have become necessary in this complicated world of today.

The convention providing for the computation centre was drafted at an international conference in Paris last December. Eight countries have already signed this convention: Belgium, Egypt, Iraq, Israel, Italy, Japan, Mexico and Turkey.

The International Computation Centre is the first of a series of United Nations laboratories which have been considered by scientists from many countries since 1946.

Despite the international character of science, there is still no methodic organization of scientific research on an international basis. In the past century, it is true, a few international scientific institutions have been created, such as the International Bureau of Weights and Measures, and the International Time Bureau. The work of these institutions, however, remains rather limited in scope.

There are many fields of science in which research work can only be organized efficiently and rationally on an international basis. This is particularly true where research requires complex and costly installations and highly specialized staff, which are beyond the means of all but the most wealthy countries. Such is the case with modern calculating machines whose work can be of service to all branches of science.

Again, where subjects of study and research can only be dealt with as a unified whole and outside the framework of any given State, as, for example, in the cases of meteorology, oceanography and astronomy, effective concentration on an international level is essential.

Such concentration is also vital when the importance of a problem, or mankind's urgent need for its solution, call for energetic and effective action. This especially applies to public health problems whose solution, in the case of certain diseases, would save millions of lives and relieve untold mental and physical suffering.

It was for such reasons as these and because of its interest in "the furthering of the development, in all sciences of research and discovery which are the essential source and stimulus of all economic and social progress," that the United Nations Economic and Social Council (ECOSOC), decided during 1946-1947 to investigate the possibility of establishing United Nations Research Laboratories.

Following consultations with the United Nations Specialized Agencies, the International Council of Scientific Unions and individual scientists and scientific bodies in many countries, ECOSOC decided to form, in co-operation with Unesco, a committee of experts to examine and report on the question.

This Committee, after considering proposals that had been made for the establishment of specific laboratories, decided to establish the four following categories of criteria for the selection of priority projects :

1. The importance of the project to humanity from (a) the practical and (b) the scientific viewpoint ; the appeal which the project would be likely to have for the public and for Governments ; whether results could be expected within a reasonable period of time.

2. The appropriateness of the project for research on the international level.

3. The amount of resources available for proceeding with the project (funds, staff, etc.).

4. The probable cost of the project and the risk of its duplicating the work of already-existing research centres.

With the aid of these criteria, the Committee recommended first priority for three projects : International Computation Centre, International Institute of Research on the Brain, International Institute of Social Sciences. It recommended for second priority four more, all of which, in its opinion, had equal claims : International Laboratory for Arid Zone Research, International Astronomical Laboratory, International Institute for the Chemistry of Living Matter, International Meteorological Institute.

The Economic and Social Council considered that the project for an International Computation Centre deserved special consideration and invited Unesco to prepare and submit a detailed plan for its creation, including recommendations as to its location, staffing, equipping and financing.

The approval of plans for the establishment of the Computation Centre by the Sixth Session of Unesco's General Conference in July last year and by ECOSOC the month after, enabled the Organization to call a Conference of interested States at which the Convention for the creation of the Centre was signed by the representatives of eight nations in December.

The Conference accepted the Italian Government's offer to house the project in the Italian National Research Council Building, all of whose library and documentation facilities will be at its disposal. The Government has also agreed to make the Centre a $75,000 free-of-interest loan for ten years.

The Centre's Member States will contribute to its annual budget which is expected to amount to about $100,000, and for the first year Unesco will make it a $15,000 grant and a loan of $60,000.

The three main functions of the Centre can be summed up as research, education and service. First, eminent scientists and a research staff working in mechanical computation, will be able to perfect, under laboratory conditions, new methods of computation. Secondly, the Centre will initiate a training scheme by giving scholarships to young research workers; mechanical computation is a fairly new science, and all countries wish to have more experts. Thirdly, scientists, scientific institutions and industrial firms in ratifying States will be able to ask the Centre staff to work out intricate calculations needed to solve scientific and technical problems.

The administration of the Centre will be shared in by all those countries wishing to participate, through a Council on which their representatives will serve.

While enjoying the moral and financial support both of the United Nations and Unesco, it will be a self - governing institution dependent only upon the States adhering to its Convention.

The first international laboratory should do much to meet the needs of many countries in various fields of science and technology. It is, in the words of M. Jaime Torres Bodet, Director-General of Unesco, "an achievement beyond the means of any single nation, but not beyond the resources of several nations acting together—where enormous, intricate machines will calculate, at inconceivable speed, the measurements of a dam, the proportions of a nuclear energy station, or the connexion between various kinds of population statistics, and where research workers will painstakingly evolve other even cleverer and quicker machines, to be the faithful helpers of all who work for the common welfare of mankind."

**A WOMAN BATHING,** by Rembrandt, photographed by filtered ultra-violet light during the cleaning undertaken in September-October 1946. A former coating of darkened varnish can be seen at (a) and (a¹). Splotches (B) and (C) under this illumination show the many layers of over-painting.

The condition of the picture, photographed on October 31, 1946 as cleaning approaches completion (left). Losses in the paint caused by former damage have been restored. Photo on right shows a specialist in the restoration of paintings at work in laboratory. (Photo Agenzia Fotografica Internazionale.)

**An X-ray shadowgraph taken in September 1927, shows the condition of the original paint 19 years before the cleaning. Crack in panel is evident at (a). Paint dragged unevenly over the surface during the original application can be seen at (b).**

**Detail photographed by filtered ultra-violet light on September 27, 1946. Old over-painting at (b) and (c) has been partly removed. It lacks the fluorescence of the original paint and there are still many dark patches or streaks to be removed.**

**Detail photographed on October 1, 1946. All except a slight residue of former varnish has been removed. Former over-painting on leg, arm and hand is also gone. Another masterpiece can once again be appreciated in its original beauty.**

# *The Care of Old Paintings*

**by Georges FRADIER**

FOR many hundreds of years, man has sought ways to protect the great masterpieces of paintings from the ravages of time. Of all works of art, paintings—whether on canvas, wood or plaster—are without doubt the most fragile. Plaster flakes off, wood rots, and canvas tears or wears away. Paints and pigments lose their brilliance, become grimy, crack and ultimately chip off. Even sudden changes in temperature can cause irreparable damage to paintings. Intense damp or dry weather, heat, cold, smoke or dust often have similar effects.

For long, two problems have faced art experts: how to protect these fragile treasures from disfigurement, and how to restore the original *éclat* to a disfigured painting.

Should the damaged parts be repainted, for example? Some 200 years ago, many art restorers did not hesitate to do so. But today's experts are quick to condemn such audacity. It is generally agreed that a picture should receive a protective coat of varnish to guard it against the attacks of the elements, and this has been widely practiced for many years. Unfortunately, for more than a century, until about 1850, it was the custom to cover pictures with a dyed varnish, producing a uniform brownish tint. This "gallery varnish" gave paintings an "atmosphere" which then seemed more romantic.

But with the years, this varnish often tended to go yellow and mixed with the colours, eliminating some of them completely. The resin varnish protected the picture, but at the same time plunged it into shadow. For even the most transparent varnish darkens as the years pass. Thus, a morning sky can be transformed into a night scene.

This is exactly what happened in the case of Rembrandt's famous masterpiece *The Night Watch*, which was the subject of one of the most extraordinary errors caused by the darkening of the varnish of a painting.

This title, which is now confirmed by custom, was not given to the work until late in the 18th century, when accumulated grime had so changed its appearance that it was no longer possible to make out what its subject was. There seemed to be a shadowy night scene, shot with gleams of artificial light, whereas Rembrandt had actually painted a company of militia setting out on a march in broad daylight.

When, in 1945, after lying for six years in shelters, *The Night Watch* was unrolled from its cylinder, it was found that a new canvas was needed. Old records were consulted in order to establish as definitely as possible the history of the canvas since its completion by Rembrandt in 1642. It was found possible to

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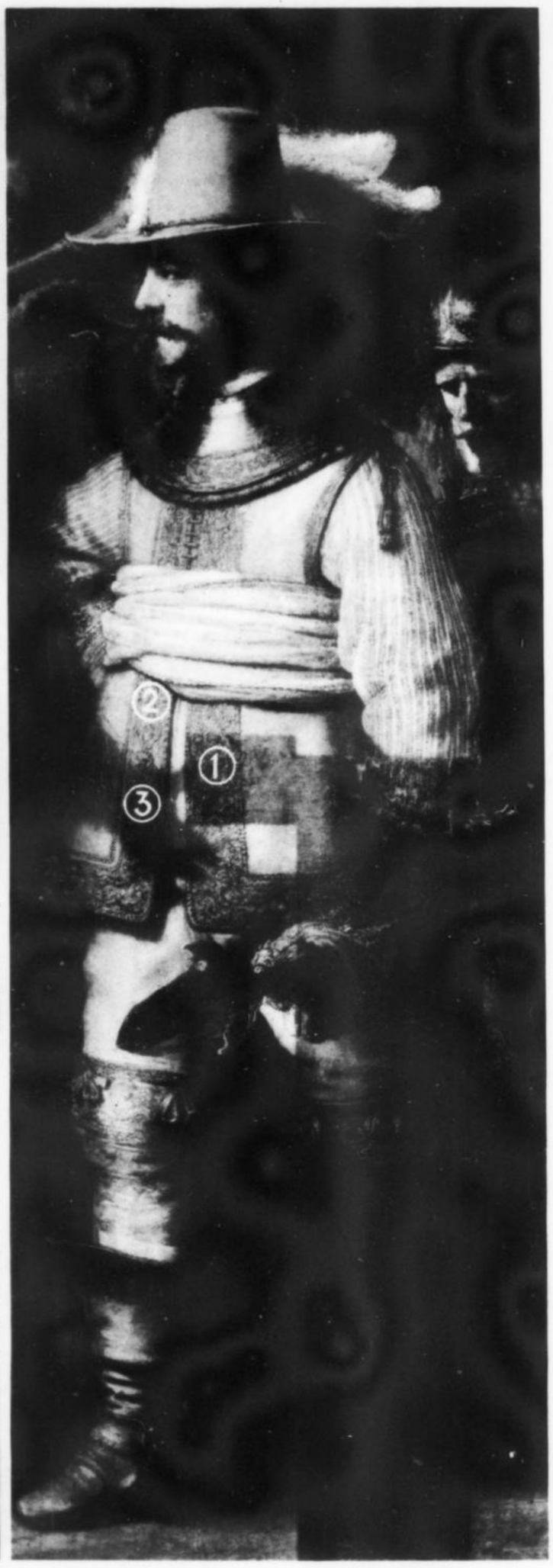
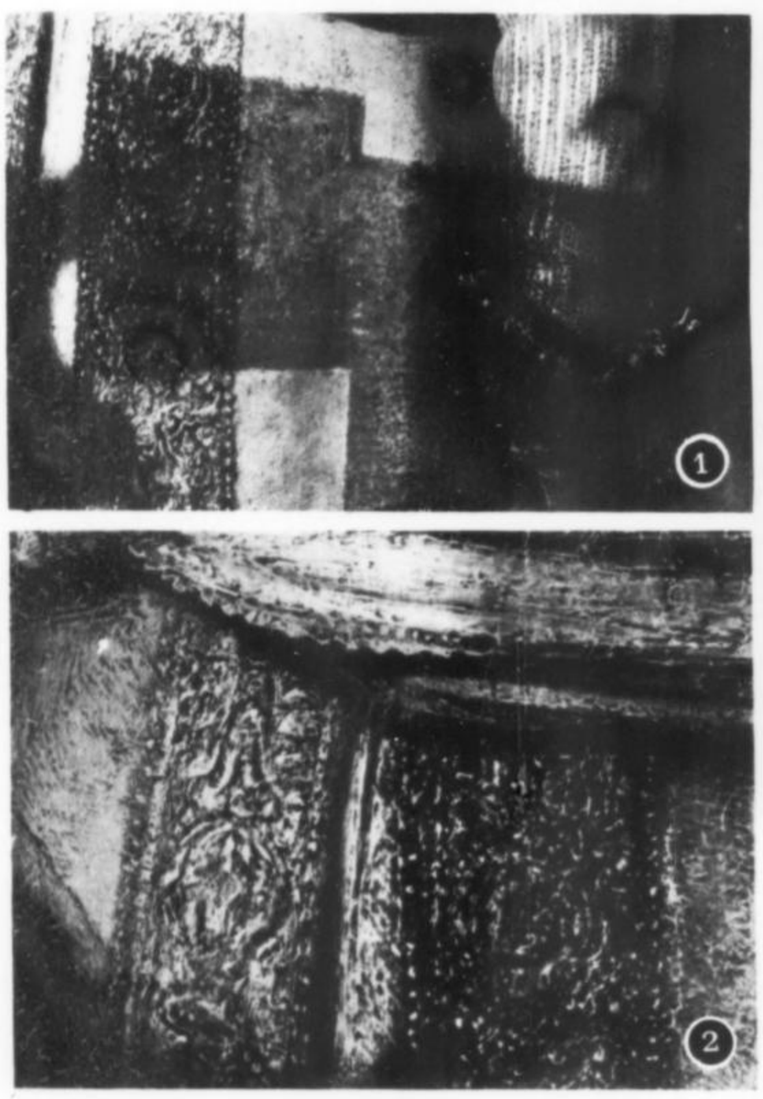
*The Company of Captain Frans Bannings Cocq*, known as *The Night Watch*, was painted by Rembrandt in 1642. This photograph was taken after the picture was cleaned.



## 'THE NIGHT WATCH' BY REMBRANDT

During the cleaning the dirty varnish still remaining on the officer's uniform contrasts with the parts that have been cleaned: (1) close-up, under raking light, of part of the strip of dirty varnish on the officers's uniform; (2) the thick layer of varnish has been removed from the embroidered border on the left, but still covers the border on the right, where it blurs finer details; (3) after cleaning, lions holding arms of Amsterdam can be seen.

*(Continued from previous page)*

draw up a chronological account containing much information about the condition of the picture and the treatment it had been given.

Notes discovered show that, as early as 1696, the masterpiece underwent periodic cleaning. One of the methods used by the painter Jan Smit was to soak the picture from the back with boiled linseed oil. In his *Guide*, dated 1758, the painter Jan van Dijk wrote that the picture had been so plastered with boiled oils and varnish that it was no longer possible to make out certain details. These details came to light only after he had removed the varnish. He admired the brilliant sunlight.

Cleaning, revarnishing, recoating and applications of boiled linseed oil, however, succeeded one another periodically every 30 years or so. Repeated complaints about the deplorable condition of the coat of varnish were made after 1851, and from the end of the last century, the picture was treated at more and more frequent intervals. This treatment consisted mainly of revarnishing with special oils and resins — copaiba and mastic — which became necessary every five or six years.

The history of all these successive operations and the application of these temporary remedies suggested that hardly any of the original coat of varnish could have survived, and that if the balsams, oils and resins which then covered the surface of the picture were removed, it would perhaps be damaged but, at least, freed of the distortion caused by the accumulated concoctions of several generations of restorers.

The Amsterdam museum authorities therefore decided that the coat of varnish should be almost entirely removed. Today, there is a rejuvenated painting, with the same striking luminous treatment of light and shade which delighted the painter Jan van Dijk when he cleaned it in 1751 and admired the high relief of the impasto, "rough as a nutmeg grater."

Nowadays, the conservation of pictures nearly always involves the removal of the varnish. And for art experts this is one of the most difficult of problems, for every case is not as simple as that of *The Night Watch*.

Is it always justifiable to remove the coats of varnish? Must they all be removed, right down to the last one? Is there not the risk of altering the original tones in trying, sometimes arbitrarily, to impart a freshness that the painter may not have desired? This old controversy has recently given rise to very animated arguments.

There are two schools of thought. One, which has been called that of the "total" cleaners, declares that all those later additions such as overpaint and coats of varnish, whether dirty, yellow or otherwise discoloured, give a wrong idea of the painting and of the artist's purpose. Accordingly, if the painting is in a suitable condition, it is, they assert, logical and desirable to remove all such foreign elements. They may quote the example of such paintings as Rubens' *Le Chapeau de Paille*, which was cleaned in 1946 by the National Gallery.

This cleaning was so severely criticized, and the *Times* published so many indignant comments from art lovers, that a commission of enquiry was set up. The experts used every modern aid in their examination of *Le Chapeau de Paille*, as well as a number of other paintings whose treatment had been criticized. Their findings (the Weaver Report) expressed complete approval of the cleaning methods used, and added, "There is no evidence of loss or of any substantial deposits of extraneous material left on the original paint."

But the "moderates" claim to be more prudent. "Radical methods do not produce the theoretical result aimed at, which is to restore the picture intact," they say, "and do not allow each stage in the gradual removal of the varnish to be watched so that the process can be stopped at the point required by the actual condition of the picture and by its safety."

They claim that radical cleaning does not achieve the desired result, since it does not restore the original picture. They point out that, under its coat of varnish, the picture has undergone various changes in the course of time. Not only have the colour values changed, but earlier cleanings, usually badly carried out, have often caused grave wear and tear.

Worse still, they say, total cleaning may alter or even ruin what remains of a picture's original condition. In addition to painting in heavy impasto, old masters, at various periods of history, used light, more or less transparent coats, scumbles, glazes or even varnishes and patination like the Italian *velatura*.

Is it certain that, in removing the varnish, damage will not be done to the surface parts

# Nations are pooling resources in the preservation of paintings

of the colour, which were designed by the artist to play an essential part in the final appearance of his work?

On this score the "moderate" school also produces its examples. When the Louvre cleaned the *Raft of the Medusa*, it would have been easy, by boldly removing the varnish, to give the foam of the waves that clear, white colour which, in the original sketches for the picture, it possessed. But, in the background, this white has been deliberately "dirtied" by Géricault with the aid of lacquer and ochre.

The artist used this patina to add to his linear perspective a perspective of values, darkening for distance. If the white of the impasto had been revealed, the result would have been a clear distortion, flouting the intentions of the artist and rendering his efforts of no avail.

Such, then, were the views which their supporters backed up with arguments involving evidence of an historical, chemical, aesthetic or radio-electrical order. While the radicals stressed the importance of technical research, their opponents laid emphasis on historical facts as well as on the sensibility of the restorer.

"The main thing," said the first group, "is to have a properly-equipped laboratory."

And the second retorted: "No one has ever had the crude notion of substituting chemical analyses for the wine taster; a trained and gifted human being has a sharpness of perception which no mechanical process can ever equal."

At this point the clash of opinions too often led to misunderstanding and confusion, so much so that it was felt that the problems should be studied in an atmosphere of co-operation, not only in the professional sphere, but also the international, for schools of thought and practices showed a dangerous tendency to become national. Thus it was that the International Council of Museums (ICOM) set up in 1948 a commission of experts from a dozen countries to obtain full information on means of conserving paintings, with emphasis on the thorny problem of cleaning.

When the commission held its first meeting in London, an observer remarked that all that seemed to separate members was "a tiny part of a varnish coating." And in fact it was not so much the general principle as the extent of cleaning which was at stake. Detailed inquiries were made, visits were arranged to the laboratories and workshops of the National Gallery, the Louvre and the Istituto Centrale del Restauro in Rome. To clear up the ambiguity of current terminology, so often a stumbling block, the ground was prepared for a general polyglot glossary dealing with the conservation and restoration of paintings.

The adoption of a general programme, the free exchange of information and the first-hand discussion of specific methods or cases were the preliminary moves towards a better understanding of these problems.

As further meetings were held — in Rome in 1949, in Paris in 1950, and in Brussels last autumn — a rapid decrease in misunderstandings and prejudices was noticeable.

Even the advocates of opposite courses who, with some exaggeration, have been called "total" and "moderate" cleaners, today admit that no one dreams of destroying what belongs to the original picture and that, when in doubt, it is best to stay one's hand, since caution should be the first and foremost guiding rule in cleaning. One and all seem to accept the existence of glazes in ancient paintings, which was unduly questioned at one time. Also, and most important of all, they grant that every case presents its particular problems and that every painting requires individual treatment.

By thus re-establishing the atmosphere of trust and understanding so essential to any progress, the International Council of Museums has brought about a true international collaboration in regard to the conservation of paintings. One of the best examples of this collaboration is provided by the treatment of the polyptych *Adoration of the Lamb*.

During the war, this masterpiece by Jan van Eyck, the "inventor of oil painting," was kept for a time at Pau, in France, and later transported to Germany, where it was discovered by the American Army in a salt mine where Hitler and Goering stored their booty of art treasures.

When it was returned to the Cathedral of St. Bavon at Ghent, the ravages of time showed so alarmingly that something had to be done quickly if the famous masterpiece of the Flemish School was to be saved. It was therefore decided that it should be given treatment at the Belgian Laboratoire Central des Musées.

Instead of relying solely on their own knowledge and skill, although these had earned them world-wide respect, the Belgian experts decided to invite the co-operation of an international group of specialists, among whom were museum heads from England, France, the Netherlands, Italy and the United States, as well as representatives of the International Council of Museums and of Unesco.

This was an initiative without precedent. As M. Georges Henri Rivière, present director of ICOM, declared at that time: "For the first time in history, a country owning an outstanding masterpiece regards itself as trustee, and summons to its aid some of the greatest specialists in the world for consultation and advice." (1)

These specialists and the Brussels experts have now finished their task. *The Adoration of the Lamb*, with its 19th century additions removed, and treated on each side with beeswax, is back in its chapel at Ghent Cathedral. Innumerable masterpieces elsewhere in the world, however, are in danger and no one has thought of assembling the proper "doctors" to treat them.

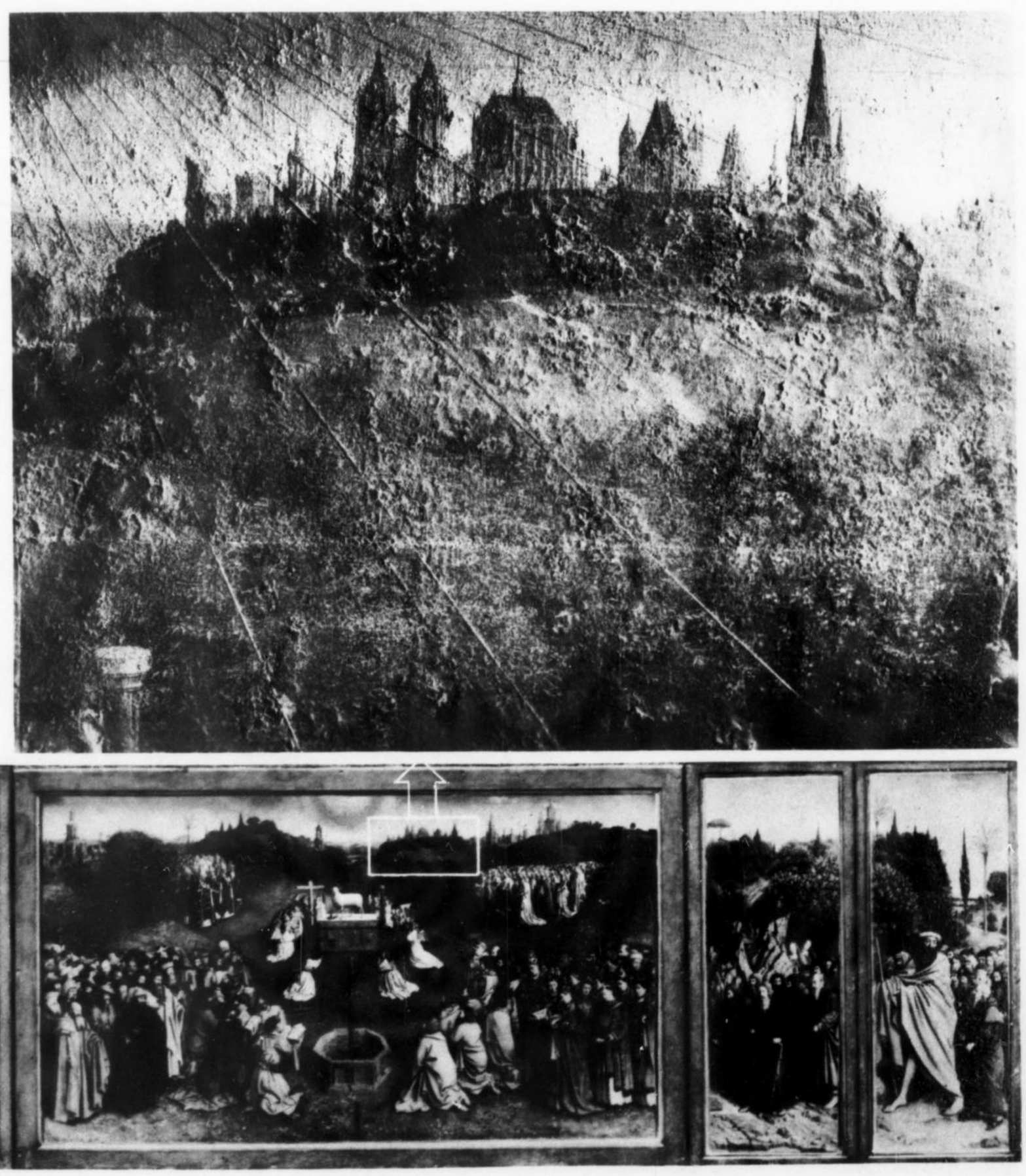
This year the Committee of the International Council of Museums is to meet in Lisbon to study a new problem: the conservation of paintings on wood which, as a base, can sometimes prove even more fragile than canvas or paper. The problems of cleaning are not, after all, the most arduous or most complicated connected with conservation.

In any case, it is certain, as Murray Pease, of the New York Metropolitan Museum of Art, has pointed out, that "no museum can hope to keep up with the task of conservation in solitary independence. The problem can be met only by the utmost in co-operative effort, by pooling resources, sharing technical data, and by resolute concentration on common fundamentals."

(1) *The Care of Paintings*, a 164-page illustrated monograph published by Unesco in 1951.

## THE ADORATION OF THE LAMB

The lower panels of **The Adoration of the Lamb**, painted by van Eyck in 1432, as it appears when open (below). At left was the Righteous Judges panel, stolen in 1934. Visitors to Ghent Cathedral, where the polyptych is housed, are chiefly interested in the strange history of this polyptych, often forgetting the quality of the work, and its importance in the birth and development of Dutch painting. They remember the wars, fires, thefts and other vicissitudes which the polyptych, now reconstituted, has survived. The artistic value of **The Adoration of the Lamb**, the learned discussions which continue to centre around it, and the difficulties which it has surmounted over a period of more than five centuries, have given this work a special fame of its own, a world prestige. Last year, a group of international experts used modern techniques to restore the masterpiece, which was deteriorating rapidly due to the ravages of time. Photo (right) shows a detail of the upper part of the central panel.



# A MODERN MARVEL:
# THE ELECTRONIC CALCULATOR

Until recently, no machine has done much to relieve man from his mental drudgery. Now machines (such as the high-speed electronic calculator in New York shown above), are beginning to take over our brainwork too — but only our second-class brainwork, the sort we can reduce to a mathematical routine, not the creative effort of the artist, thinker or research scientist. As this new trend develops, we can foresee a world in which everyday routine work and its drudgery, whether manual or mental, have been taken over by machines. For the fascinating story of these new machines, and of the men who have developed them, SEE PAGES 8 TO 12.